

AFIT/GIR/LAL/97D-5

THE ONE WITH THE MOST INFORMATION WINS?
THE QUEST FOR INFORMATION SUPERIORITY

THESIS

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AFIT/GIR/LAL/97D-5

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19980123 091

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THESIS

Presented to the Faculty of the Graduate School of Logistics
and Acquisition Management of the Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Information Resource Management

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Captain, USAF

December 1997

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Acknowledgments

First, I would like to thank my father, who told me that if he could get an advanced degree, it should be easy for me, and my mother, who continually assured me that God has a plan for my life (it appears the plan did include finishing this thesis, after all!) I would also like to thank my (former) commander, Lt Col Glenn Watt, who was responsible for planting the thought in my mind that resulted in my applying for AFIT and having the opportunity to go through this exhilarating experience.

Thanks also go to my thesis advisor, Major William Scott, who stood by me throughout (in sickness and in health). His well-timed comments allowed freedom of thought while still keeping me on track. My reader, Dr. Alan Heminger, should also be recognized; his insights into the field of IRM engendered the seeds which grew into the ideas central to this research.

Finally, special thanks are due to my husband, Roy Caligan, and my daughter, Rebecca Jean. Beginning with her unexpected appearance in the middle of my AFIT tour, Rebecca always made sure I took breaks from my schoolwork. I could not have managed without Roy, who kept me from having to take too many breaks. His support, encouragement, and self-sacrifice made it possible for me to stay the course, despite interruptions and distractions, completing thesis and the AFIT program all on time. All right, Roy and Rebecca, *now* we can do something together!

Captain Stacy M. Clements

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Abstract

The escalation of interest in information as a corporate resource is reflected in the military's quest for information superiority. A volume of directives, articles, and doctrine is appearing to meet the unique challenges presented by information as a resource. Discussions of how to achieve information superiority have given rise to investigations of such related concepts as information warfare and information operations, with associated taxonomies and ideas of how to use information capabilities for attack and defense. Included in the equation is the quantity of dollars spent on information technology in an attempt to exploit information resources.

This thesis examines information superiority and the related concepts, and examines current information technology initiatives in order to discern the characteristics which can aid in the quest for information superiority. A synthesis of the most prominent perspectives on information superiority is formed. In the context of this definition, a process model of information superiority and its necessary activities is developed, with acquisition and decision making identified as key. The idea of information technology as enabling information superiority is probed, and an alternate view proposed; contending that information technology is more likely to be detrimental to information superiority unless certain criteria are met. The resulting conceptual model depicts the key attributes of information superiority and information technology, and represents the relationships between these concepts.

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I. Introduction to the Research

Background

With the advent of the “information age,” the demand for data and the technology to extract and assemble that data into usable information has become a prominent military concern. Information is now recognized as a strategic resource, not only by corporate America, but also in the military sector. This growing recognition of the importance of information has been mirrored by the rapid development and expansion of information technologies—methods to increase our capability to process and communicate information and knowledge. The Air Force, acknowledging the increasing importance of information, recently declared *information superiority* to be one of the core competencies in its new vision of Global Engagement (DAF, 1996). We are entering a “third wave” of society, a wave in which “a revolution is occurring that places knowledge, in various forms, at the core of military power” (Toffler, 1993:69). This revolution in military affairs (RMA) marks the realization by the military that information and information technologies must be included in the weapons inventory used to achieve national objectives via military activity.

Establishment of information superiority as a critical factor in mission accomplishment requires the development of new concepts and the integration of old and new ideas. Application of information as a force adds a new dimension to the field of competition or the battlespace (Fogleman, 1995; Link, 1995). In this new dimension, called the *infosphere*, information is the central strategic resource. Domination of the infosphere requires superior use or manipulation of information, achieved through *information operations* (IO). In the Department of Defense (DoD), this shift in the application of war has resulted in evolution of the concept known as *information warfare* (IW). For the military, inability to compete in, control, and exploit the infosphere is as perilous as lacking an adequate land, air, or sea force. Information superiority alone may not allow us to win a conflict, but information inferiority will almost certainly cause us to lose (Campen, 1992; DAF, 1996, Link, 1995). The importance of information lies chiefly in its association with decision making. While the decision making process allows an organization or entity to determine how to deploy resources in order to accomplish an objective, good information resources and efficient, competent use of information are necessary to effective decision making. An understanding of the relationship between information and decision making is an important element in establishing information superiority. The continuing explosion of information technology is another variable which must be considered. Information technology is intended to improve information processing and communication abilities, resulting in better decision making which in turn leads to the accomplishment of specified goals (i.e.

information superiority). Exploration of this idea forms the primary motivation for this thesis.

Information as an adjunct to conducting war is not a new concept; in fact, intelligence gathering and psychological operations are ancient ideas. As far back as Biblical times, armies sent out reconnaissance personnel to gather information, or attempted to block critical knowledge from their enemies. Historically, military theorists such as the Chinese general Sun Tzu (circa 500 B.C) and the German thinker Carl von Clausewitz have recognized information as an inherent part of war, and included this realization in their theories. Why, then, the sudden upwelling of interest in information operations and information warfare? Operation Desert Storm can serve as an example. It has been touted as “the first information war,” a conflict in which “*knowledge* came to rival weapons and tactics in importance” (Campen, 1992:10). Although not perfectly executed from an information perspective, Desert Storm certainly stands on the cusp between second and third wave warfare as the first conflict in which information was a *primary* military target (Campen, 1992). It also illustrates the advantages of superior information and information technology, along with exposing serious problems resulting from shortfalls in this area. A lack of accurate, timely information can be as detrimental to a military operation as a shortage of physical supplies—witness the Iraqi demoralization after disruption of their communications and command and control systems (Mann, 1994).

Information warfare is not a discrete technique of conducting war; it is comprised of several different facets, and even these are viewed differently by different segments of

society. Offensive information warfare is considered to involve degrading or destroying an adversary's information infrastructure. The generally accepted view of defensive IW includes actions taken to protect systems and information from attack (DAF, 1995a; Dishong, 1994; Schectman, 1996; Schwartz, 1996). Other aspects, such as electronic warfare, psychological operations, battlespace management, and virtually any type of operation which uses information systems coalesce around the concepts of information warfare and information operations. All types must be mastered in order to achieve indisputable information superiority. No matter what the form, one of the basic premises of information warfare is the importance of decision-making in conducting war. If a commander can make better decisions more rapidly than his opponent, he can win the battle. In order to make the best decision possible in a limited amount of time, a commander must have quick access to accurate information.

The need for information systems technology to gather, manipulate, and store the masses of data used in the Air Force has long been recognized (Phelan and McGinnis, 1996. Radford, 1978, United States Congress [ITMRA], 1996). The Air Force maintains a plethora of information systems and databases in a number of functional areas, including operations, logistics, personnel, medical, and support functions. For many years, the military has taken advantage of the ready availability of information systems and applications, but there has been no overarching strategic plan for allocating and managing information. We are now facing the consequences of this deficiency. It is often difficult for a commander to obtain quick, integrated information to assist in decision making. Interoperability of systems and the capability to share data and

communicate information across functional areas has become a major area of concern in today's military (DII SHADE Capstone Document, 1996). Information superiority is the cornerstone of various efforts presently being pursued by the Air Force and the DoD; systems and architectures are being designed to provide commanders and warfighters improved communications and swift, easy access to necessary information. This research will examine several of these initiatives, including the overarching command, control, communications, computer and information for the warrior (C⁴IFTW) concept and its associated technologies, the Army's advanced warfighting experiment, and Joint Warrior Interoperability Demonstration 1997. Presumably, proper use of these systems will help to tighten the commander's decision making process, thereby contributing to the attainment of information superiority. An examination of research relating information and decision making reveals implications which should be studied for their application to the Air Force goal of information superiority.

Research Objective and Scope

The objective of this research is to develop propositions supporting the achievement of information superiority in the military. In keeping with this objective, this thesis will explore the concept of information superiority and its attendant activities, and it will examine methods being used and pursued in the military toward the attainment of information superiority. There is a notable amount of literature discussing aspects of information warfare/operations and the implications of viewing information as a strategic asset, but little leading to a commonly acceptable definition of information superiority.

Studies also exist relating the use of information and information technology to aspects of decision making. While there is some research extant regarding the results of information technology with respect to corporate information advantage, there is none which specifically addresses the characteristics of this technology relevant to the military's requirement for information superiority.

If properly used, information technology has the potential to improve decision making at all levels of war. However, the specific concerns and methods can be expected to vary among the levels, as the levels have different spans of control, time constraints, and immediate objectives. The strategic level is focused on establishing and supporting national policy through high-level strategic objectives. The tactical level is concerned with the details of battles and engagements, translating combat power into actions which allow an advantage to be gained over the engaged enemy. Combat is the means to achieve goals set at the operational level. The operational level involves the employment and direction of military forces in order to gain an advantage over an adversary and meet strategic objectives in a given theater of operations and within a specified time. The operational level must knit together the overall goals set at the strategic level with the specific actions that result in success on the battlefield at the tactical level. According to Air Force Manual 1-1, the military professional should have a special understanding of the operational level of war (DAF, 1992b). Therefore, this thesis concentrates on the military decision maker at the operational level. Since the operational level incorporates aspects of the strategic and tactical levels, the advantages gained by an operational decision maker's use of information technology should have a certain amount of

applicability to strategic and tactical decision makers. In particular, each level involves both planning and implementing strategy. Planning includes "analyzing the situation, estimating friendly and enemy capabilities and limitations, and devising possible courses of action," while implementation of strategy involves constant reevaluation, adaptation, and exploitation of dynamic situations (DAF, 1992b:44).

This research focuses on a single decision maker, rather than a group. There is little rigorous research available on how military decisions are made. A search for literature on military decision making yields writings on high-level policy decisions associated with national activities, such as the VietNam conflict or World War II and the ensuing cold war. There has been some writing about decisions made by commanders in the field (i.e. Generals Douglas MacArthur, Dwight D. Eisenhower, and Omar Bradley), generally in historical studies of the campaigns they directed (Greenfield, 1990). Although the civilian sector is in many cases shifting its focus to collaborative or group decision making (Cammarano, 1994), the command structure in the military is much more conducive to having a single decision maker. A military commander may solicit suggestions and take advice from his staff and subordinates, but in the end, the decision is his to make. The ability to make a decision and stand accountable for it is one of the essential aspects of leadership. Although the group process may apply more at the strategic level (where national policy is determined and politics play a part in what decisions are made), at the operational and tactical levels, good military commanders do not make decisions by committee.

The boundary-spanning activities involved in planning and implementing strategy correspond loosely to models of rational decision making. Although rational decision making models are prescriptive in nature, excluding considerations such as personal bias, a model of this type can be useful for showing the relationships between information superiority, information technology, and decision makers. Despite the limitations, a rational decision model can be used to demonstrate the principles set forth in this research regarding the ability of information technology to improve decision making and assist in attaining information superiority.

Specific Statement of Research Problem

Given the scope of the research as defined in the previous section, it is necessary to rephrase the basic research problem of determining how information superiority can be achieved. Based on the identified scope, the research problem can be amplified and stated as follows:

What activities are essential for the attainment of information superiority, and how can we apply information technology in support of these activities?

Organization of the Research and Research Questions

In order to address the research problem, it is necessary to explore each of the concepts involved in the problem along with the relationships between these concepts. Information superiority will be the first idea examined, along with its supporting concepts, information warfare and information operations. The decision making process and associated models of decision making will be explored, in order to consolidate a

rational decision model to use in exploring the research problem. Current information technology initiatives will also be studied. Relationships between information superiority, information warfare, and information operations will be defined, and the associations between these concepts and the decision making process will be delineated. Finally, this research will examine factors involved in the relationship between information technology and the attainment of information superiority.

Despite the numerous discussions of information superiority, IW, and IO, some of which have been hinted at in this chapter, there is no universally accepted definition of these concepts. The purpose of this research is to establish an understanding and a working definition of each concept, explore the connections between them, and develop propositions for consideration in the effort to establish and sustain information superiority. In investigating this research problem, the following research questions must be answered:

1. What are information superiority, information warfare, and information operations, and how are these concepts related?
2. What are the principal activities required for information superiority, and how can we manage these activities to achieve this goal?
3. What role does information technology play in promoting information superiority?

Methodology

Since this research is exploratory and focused mainly on organizational issues, qualitative methodology is used. A review of the pertinent literature is used to develop an understanding and working definition of each concept. Examination of the literature,

relevant experiments and studies, and interviews are used to develop specific propositions concerning information superiority, its component activities, and the role information technology plays. Analyzing the technology and events in the context of their organizational surroundings is expected to yield a better understanding of the activities to concentrate on and how information technology can be used in support of information superiority in the military.

Summary

In order to present a proper context for the research problem, this thesis analyzes literature dealing with information superiority, information operations, and information warfare. Based on the information gleaned from this literature review, these concepts are defined and the relationships between them delineated. This thesis also examines decision making theory and defines a decision making model for use in investigating the research problem. A link is established between the information concepts, the decision making process, and information technology, providing a framework in which to examine and draw conclusions about ideas to consider in using information technology as an adjunct to decision making and activities supporting information superiority. These conclusions are used to develop a refined conceptual model of information superiority, illustrating the key activities and the role information technology can play.

This chapter introduced the need for information superiority and the notions of information warfare and information operations, along with the idea that decision making is a major element of these concepts. It also identified the idea that information

technology may be an aid to processing and communicating information for decision making and other activities intrinsic to information superiority. The next chapter will explain the methodology used to perform this research. Chapter III is a review of the literature surrounding the concepts examined in this paper, while Chapter IV presents an analysis of the information gathered, along with a series of propositions relating to the research question. Finally, Chapter V presents the conclusions in the form of a conceptual model synthesizing and illustrating the relationships defined by the propositions. It also includes related recommendations, suggests areas for further study, and comments on the relevance of the findings to military goals and activities.

II. Research Design and Methodology

Research Design

The motivation for this research was a wish to explore the currently popular concept of information superiority and its related components of information warfare and information operations, along with the emerging idea that information technology may provide a means to achieve information superiority through improving its associated activities. A qualitative data collection and analysis model was used to examine literature dealing with these concepts and related issues and explore information technology in a field context, in order to set forth a set of propositions concerning the relationships between information technology, information superiority, and its inherent activities, including decision making.

An exploration of these concepts and their relationships is particularly well-suited to a qualitative approach. Information systems research dealing with organizational and managerial issues lends itself well to qualitative methods, especially the case study; in fact, “the case study research method is particularly well-suited to IS [information systems] research” (Myers, 1997:n. pag.). A qualitative approach allows the researcher to discover patterns through observation and analysis of qualitative data; it is a method of discovery rather than explanation (Maykut and Morehouse, 1994). Data collection, analysis, and theory have reciprocal relationships; in a qualitative approach, the researcher does not begin with a hypothesis or theory and prove it, but rather begins with an area of study and allows the ideas relevant to that area to emerge (Strauss and Corbin,

1990). Discovery or development of theory involves an inference from data or observations suggesting an underlying general principle of causality, method of operation, or relationship to other phenomena. "The question of the appropriate methodology for studying technological impact is woven into issues of theoretical substance much more tightly than people might realize—or prefer" (Weick, 1984:129). When studying issues in which exploration and discovery is of primary importance, a qualitative approach is appropriate.

A characteristic of qualitative research is an emergent design, in which data collection and analysis are simultaneous, interactive processes. This allows for broadening or narrowing of the focus of inquiry (what is being studied) in order to include more detailed information or concentrate on specific areas of interest, as necessary (Maykut and Morehouse, 1994; Miles and Huberman, 1994). The only items specified at the beginning of the study were the basic concepts which would be explored—information technology, information superiority, and decision making—and the idea that there was some relationship between these concepts.

Developing the Focus of Inquiry. A preliminary step to data collection involves defining the focal point and boundary of the matter under study. A research effort has a heart, or focus, and a moderately indeterminate boundary which circumscribes the investigation. The area inside the boundary constitutes the setting, concepts, sampling, and other concerns of the study (Miles and Huberman, 1994). In qualitative research with an emergent design, this model is subject to change as the interactive, iterative activities of data collection and analysis proceed. A common way of determining the initial focus

of a qualitative study is to draw a cognitive map. The following cognitive map (initially created using a qualitative research software program called Inspiration®) served as the starting point for this research. The first cognitive map was freeform, while the second shows how Inspiration® 5.0 organized the main ideas based on the links between the concepts.

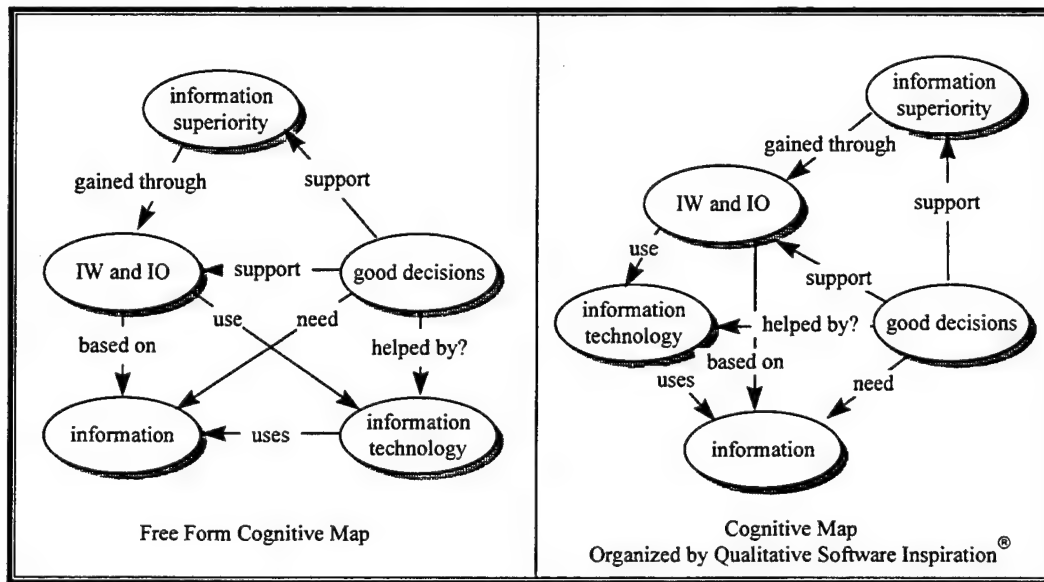


Figure 1. Cognitive Maps of Research Concepts

In the parlance of the quantitative paradigm for research, information superiority, which is gained through information warfare and information operations, would be the dependent variable, moderated by decision making, which is affected by information and information technology. However, in the context of this qualitative research, information superiority is the outcome we desire. Information superiority is the heart of this research, and the setting to explore is the concepts surrounding information superiority, including

the operational decision maker. The boundary of this research effort is information technology. Figure 2 portrays the territory covered by this research effort.

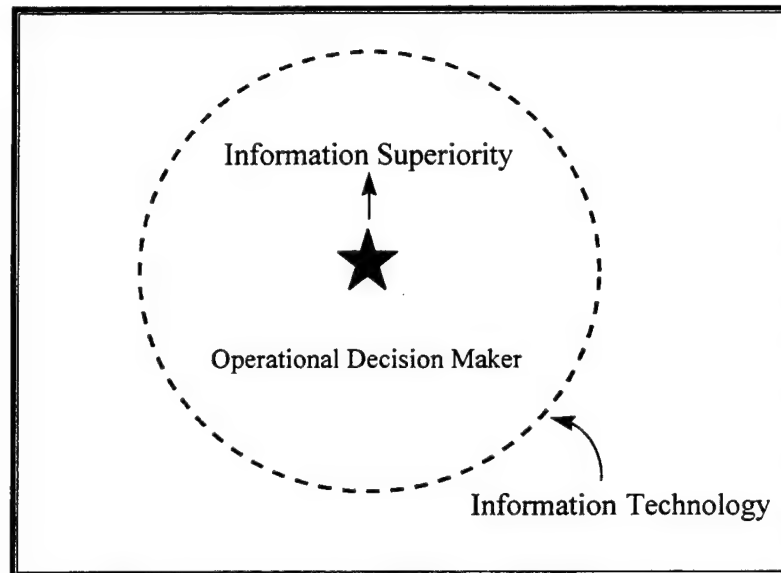


Figure 2. Area and Boundary of this Research

Provisions for Trustworthiness. Qualitative studies are difficult to replicate, as they involve evaluation and interpretation of detailed textual information, rather than numerical data appropriate to quantitative statistical analysis. However, the lack of statistical techniques does not equate to lack of rigor or validity. Maykut and Morehouse (1994) suggest several methods for increasing the trustworthiness of qualitative research findings, including multiple methods of data collection, building an audit trail, and working with a research team.

This research used various methods of data collection. The majority of data was obtained from reviews of relevant literature and documents, but some data was collected from field observations and personal interviews. The conceptual map and emergent

framework noted in this research forms part of the audit trail. The trail is augmented by the specific descriptions of search methods described in the data collection segment of this chapter. Due to the guidelines for an AFIT thesis, it was impossible to work directly with a research team. However, the thesis committee served as an outside debriefer, raising questions about the conclusions drawn and steering the focus of the research. In addition, many of the propositions were introduced and discussed in apropos graduate classes; attention to the diverse viewpoints of seventeen other graduate information resource/systems management students assisted in rooting out unwarranted bias.

Methodology

The specific methodology used in this endeavor was the interactive data analysis model propounded by Miles and Huberman (1994). This model includes four different interconnected processes: data collection, data reduction, data display, and conclusion drawing and verification (see Figure 3).

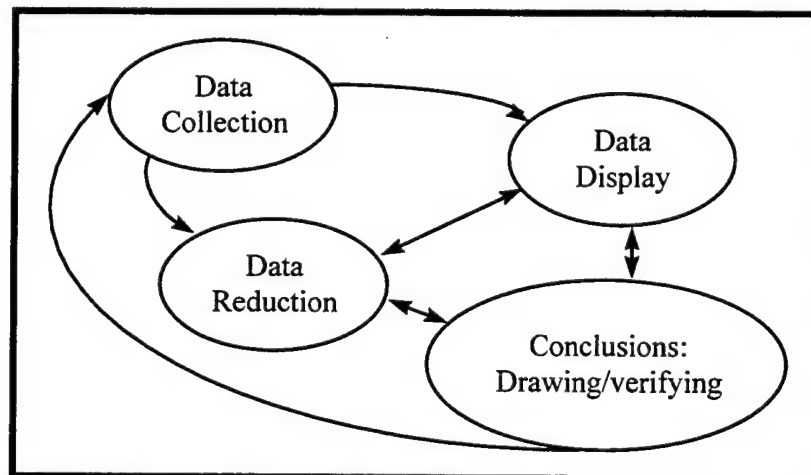


Figure 3. Interactive Model of Data Analysis (Miles and Huberman, 1994)

Although data collection is not strictly a part of analysis, it is an ongoing process that spans much of the period during which analysis is being performed, hence its inclusion in the model. The flow model shown in Figure 4 shows the concurrent activity flows of data analysis components.

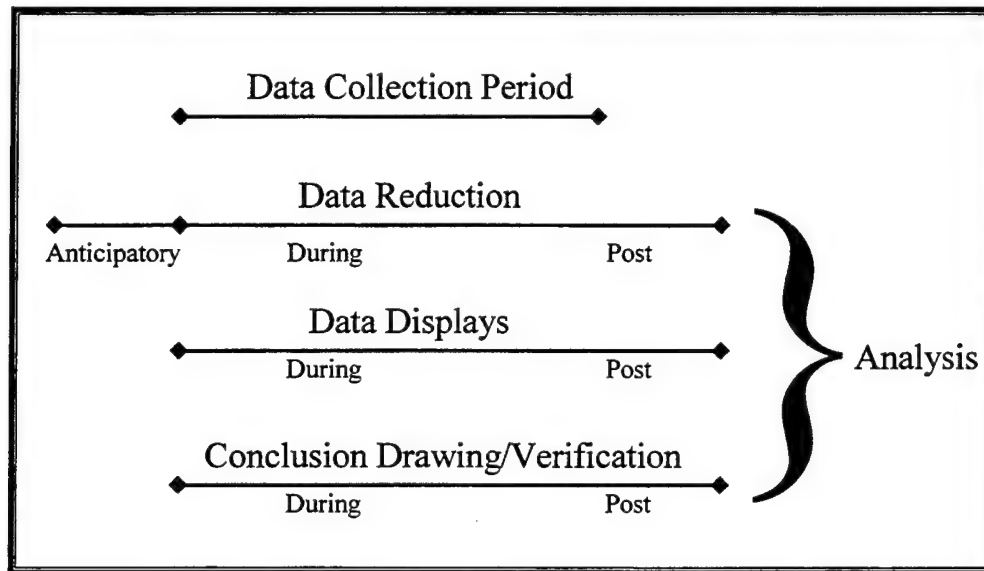


Figure 4. Components of Data Analysis: Flow Model (Miles and Huberman, 1994)

The process of data collection is self-explanatory. In this study, data collection involved researching the notions of information superiority, information warfare, and information operations, along with an examination of decision-making theory. Additionally, information relating to information technologies being used or developed in the military was gathered. Data reduction is the process of abstracting and transforming collected data. This is an iterative process which occurs continually for the duration of any qualitative research project. As shown in Figure 4, anticipatory data reduction takes place even before data collection is initiated, as a necessary adjunct to formulating the research problem. Data reduction involves discerning patterns in collected data, and

focusing and organizing data in such a manner that conclusions can be drawn. The next step in analysis, data display, complements this process. The organized information is assembled in a format which allows the final step in analysis, conclusion drawing and verification, to be accomplished (Miles and Huberman, 1994).

Conceptual Framework. As the study evolved, the original conceptual map and focus of inquiry served as the basis for development of a more formal conceptual framework to assist in directing the research and data analysis effort. According to Miles and Huberman (1994), a conceptual framework categorizes the areas and concepts to be studied and depicts the presumed relationships among them. It represents a more detailed view of the focus and bounds of the research. Strauss and Corbin (1990) agree, stating that conceptualizing data is the first step in analysis. The conceptual framework used in this study was expanded from the cognitive maps initially developed; it is displayed in Figure 5. This framework was used to structure the data collection, reduction, and display processes.

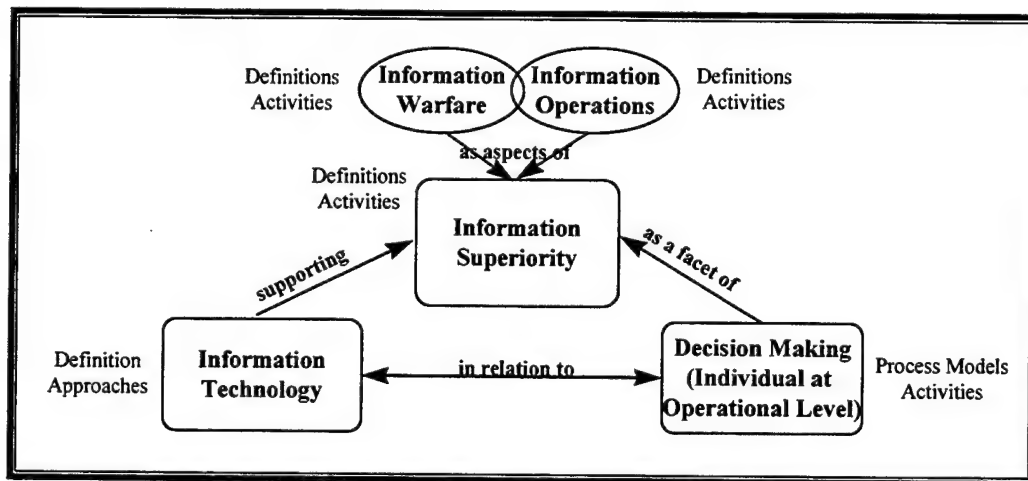


Figure 5. Conceptual Framework

Information superiority is the heart of the research. The other ideas are explored in connection with information superiority and its related concepts.

Anticipatory Data Reduction. In this study, anticipatory data reduction took place at the time the research focus of inquiry was formulated. The conceptual map shown in Figure 1 assisted in determining the boundary of the research as depicted in Figure 2. These two exercises served as preliminary data reduction, helping to sketch out the research problem and provide a starting point for data collection.

Data Collection. Information was gathered on each component identified in the conceptual framework: information superiority, information warfare, information operations, decision making, and information technology. The intention was to amass enough information to define and explain each term and delineate the relationships between them. Information warfare and information operations were included, as these ideas are inextricably linked with the concept of information superiority.

The main method of data collection used was a review of pertinent literature and documents. This was accomplished by the use of several search methods. The method which produced the greatest quantity of useful literature and documentation was inquiries into the FirstSearch reference service. This service contains numerous databases containing indexes of books and materials from libraries throughout the world, including nearly 12,500 journals. Another profitable method was keyword and subject searches of local library catalogs. Finally, the World Wide Web (WWW) yielded a number of useful documents. The WWW searches were performed using a number of search engines and meta-search engines. Table 1 shows the main sources searched, along with the specific

search databases or engines included in each source. The table also shows the terms used to execute the keyword and subject searches in all sources examined.

Table 1. Sources and Terms Used for Literature Search

Main Source	Specific Areas/Engines	Terms
FirstSearch	WorldCat (books and other materials) Article1st (index of journal articles) FastDoc (index of online articles) PapersFirst (index of conference papers)	information superiority information warfare information operations information technology
Libraries	AFIT Library (catalog, electronic journals) Wright State University Library (catalog, periodical index, electronic journals) Greene County Library Montgomery County Library	information systems information sharing data sharing decision making decision models rational decision models decision theory
World Wide Web	Infoseek WebCrawler Excite Lycos The Open Text Index Dogpile (includes Yahoo, Lycos' A2Z, Excite Guide, Go2.com, WWW Yellow Pages, PlanetSearch, Thunderstone, What U Seek, Magellan, Lycos, WebCrawler, InfoSeek, AltaVista, Excite, HotBot) MetaCrawler (includes Lycos, Infoseek, WebCrawler, Excite, AltaVista, Yahoo) EchoSearch (includes AltaVista, Excite, HotBot, Infoseek, Lycos, OpenText, Pathfinder, WebCrawler)	

One difficulty encountered during the literature search was the number of items returned by the search engine based on the query term. This was not a problem with the library catalog searches, but was a significant challenge encountered with the use of FirstSearch and the WWW. Searches were refined and limited by use of Boolean queries,

grouping the search criteria in order to limit responses to the area of interest. The search terms were separated into three groups, as shown in Table 2, and further searches were performed by combining items from two different groups in a Boolean inquiry (i.e. information technology AND decision making). Searches were made using each combination, with varying results. The terms information and decision were added in order to refrain from excessive restriction of the combination searches. An additional limiting factor, the term *military*, was later included with the basic terms and the combinations yielding the most useful returns.

Table 2. Grouping of Terms for Boolean Searches

Information Concepts	Technology	Decision Making
information superiority information warfare information operations information	information technology information systems information sharing data sharing	decision making decision models decision theory decision

The primary limitation encountered was the availability of documents identified through FirstSearch. Many documents were received through interlibrary loan, but a few items that might have been pertinent could not be obtained.

Additional methods of data collection involved electronic mail correspondence and telephone interviews with people who had experience or knowledge about information technologies. One surprisingly valuable source was the C⁴I-Pro listserv. Upon subscribing to the list, the researcher posted a request for any information dealing with the problem addressed in this research. A number of responses were received,

suggesting additional sources for information. Some respondents sent documentation and personal comments about their experiences with various information technologies, and a few of these were contacted for mini-interviews. Another source of data was personal contacts with former colleagues. In some cases, they had information pertinent to this research, or they provided references to others who had knowledge of value. Personal comments and electronic mail received from these sources was also useful information which assisted in the analysis and conclusions presented in this research. Additionally, information presented and discussed in several AFIT graduate information resource management classes and projects was contemplated, and may be considered as part of the data collection and analysis procedure experienced in this research process.

Case Studies. Some of the information gathered through class projects and the documentation and interviews obtained from the C⁴I Pro listerv responses lent itself to the case study approach. Several of the propositions developed in the analysis stage are supported by case study vignettes. These case studies were accumulated as a convenience sample (the settings which were readily available) or through the snowball technique (where one participant suggests another, as in the information gleaned from responses to the query posted on the C⁴I Pro list). However, although the formal method was not used, the cases tend to meet the criteria of maximum variation sampling, in which the researcher seeks understanding of a phenomenon by examining settings representing the greatest differences in that phenomenon (Maykut and Morehouse, 1994).

Data Reduction. The data reduction process was concurrent with data collection. Restriction of data searches through Boolean searches was a type of data reduction, but

the principal means of data reduction was personal review of the documents acquired.

The conceptual framework shown in Figure 5 served as the basis for focusing and organizing the data. Data was organized according to the following topics:

- Data examining the basic concepts and related ideas examined in this research (information superiority, information warfare, information operations, decision making, and information technology)
- Data showing relationships between the information concepts
- Data discussing relationships between the information concepts and decision making
- Data discussing relationships between information technology and decision making
- Data discussing relationships between the information concepts and information technology

The data reduction process also helped to identify areas that needed a narrower focus. In particular, a study of decision making theory and models provides a vast array of information which precludes a reasonably focused area in which to develop theoretical principles. In this research, rational decision making process models were selected as the locus of study. Decisions are also categorized in various ways at different levels, and they may be made by groups or individuals. In order to narrow the scope of this research, the level of analysis chosen was the operational level, and the unit of analysis was the single decision maker.

Summary

This chapter presented the methodology used to answer the research questions posed in this study. Research was centered around the qualitative model of data analysis outlined by Miles and Huberman (1994). Included in this chapter were the concept map, the focus and boundary model, and the conceptual framework used to define and direct this research, in addition to an explication of the methods used for data collection and reduction. The last two facets of the qualitative model, data display and conclusion drawing/verification, are addressed in the following chapters.

III. Literature Review and Definition of Concepts

Introduction

The focal point of this research was to determine how we can achieve information superiority through exploitation of its intrinsic activities and application of information technology principles. This primary question engendered a number of other questions which had to be answered prior to delving into the principal research question. To establish a context in which to discuss the influence of information technology on decision making and information superiority, it is first necessary to define these concepts. Inasmuch as information superiority can be considered as the goal we are trying to attain, it is reasonable to begin by defining this idea. The related ideas of information warfare and information operations will also be explored. Since there are numerous perspectives on these concepts, exploration will take the form of reviewing the literature for some of the most prevalent definitions and extracting the common themes from these definitions. The purpose of this effort is to generate an understanding of each idea in terms of its focus, objectives, and approach, so the concepts may be examined in relation to the decision making process and information technology. Exploration and association of the decision making process with information technology and the information concepts creates the framework bounding the conduct of this study. The data collection and reduction processes undertaken in this survey effort provide an answer to the first research question—what are information superiority, information warfare, and

information operations, and how do these concepts relate?—and define the elements of the conceptual framework used as a basis for this study.

Literature Review

Information Superiority. Information superiority, also referred to as information dominance, is consistently set forth as the result of successful information operations and information warfare, and there are numerous discussions of what is needed in order to achieve this result. The new Air Force vision, encapsulated in *Global Engagement: A Vision for the 21st Century Air Force*, presents information superiority as one of the service's core competencies. It does not specify precisely what this concept entails, but it does set forth requirements which must be met to obtain information superiority. In order to attain dominant battlefield awareness, the military must keep pace with the rapidly expanding technology changes in the realm of information. The Air Force must have a "truly interactive common battlespace picture...its future Battle Management/Command and Control (BM/C²) systems will enable real-time control and execution of all air and space missions. The Air Force will also ensure that its information systems will be fully interoperable for seamless integrated battlespace management" (DAF, 1996:14). An earlier Air Force document does provide a concise definition of information dominance, "a degree of superiority in information functions that permits friendly forces to operate at a given time and place without prohibitive interference by the opposing force" (DAF, 1995a). Another Air Force source defines information dominance as "a superior (relative) understanding of a (potential) adversary's military, political, social, and

economic structures” (Hutcherson, 1994:53). This definition foreshadows the concerns and taxonomies examined later in definitions of information warfare.

In its Field Manual (FM) 100-6 covering Information Operations, the U.S. Army defines information dominance as “the degree of information superiority that allows the possessor to use information systems and capabilities to achieve an operational advantage in a conflict or to control the situation in operations short of war, while denying those capabilities to the adversary” (DA, 1996:n. pag.). The Army definition is related to the DoD definition of information superiority: “That degree of dominance in the information domain which permits the conduct of operations without effective opposition” (DoD Dictionary, 1997:n. pag.). However, the Army expands on the definition, clearly pointing out that information superiority lends an advantage in both wartime and operations other than war (OOTW), through the acquisition, use, exploitation, protection, and management of information activities (Thomas, 1996). Captain David M. Link further amplifies this definition in his white paper supplementing FM 100-6. He states that information dominance is a delta, the difference between the information available to opposing commanders. However, information dominance does not involve information by itself, but hinges on the difference in *understanding* the information in the context of a specific purpose. Captain Link terms this “battlefield visualization.”

Battlefield visualization is the process whereby the commander develops a clear understanding of his current state in relation to the enemy and environment, envisions a desired end state which represents mission accomplishment and then, subsequently, visualizes the sequence of activity that will move his force from its current state to its end state...the commander whose level of battlefield visualization is greater has “information dominance.” (Link, 1995:n. pag.)

In addition, Link notes that there are variations of information dominance ranging from “information supremacy” to “information parity,” and observes that information dominance may be attained operationally, yet still lost at the tactical level. He also comments on the fact that an important feature of battlefield visualization is decision making tempo.

These military views are reflected in *Joint Vision 2010*, which defines information superiority as “the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary’s ability to do the same” (CJCS, 1996:16). This conceptual plan, which is intended to encompass all branches of the military, goes on to state that information superiority requires both offensive and defensive information warfare.

The military services are not alone in their pursuit of information superiority. Information superiority is viewed as a competitive advantage in the corporate world. Witness this simple definition: “Information dominance exists when the user has that ‘warm, fuzzy’ feeling that a competitive advantage has been obtained over an opponent” (Cherney, 1997:n. pag.). Civilian corporations were among the first organizations to realize information could be leveraged as a resource. Information is now one of the keys to a corporation’s competitive position; to a business, information is money. The connection between economic organizations’ views and the military perspective of information superiority is reflected in the Toffler’s book, *War and Anti-War*. This book explores in detail the idea that “the way we make war reflects the way we make wealth”

(Toffler, 1993:3). Following this theme, we can consider the notion that if information provides a competitive advantage in business, it should also do so in the military.

It is important to note that simply having more information or more and better information technology will not result in information superiority. As noted by Craig L. Johnson,

[I]nformation dominance is not “my pile of information is bigger than yours” in some sort of linear sense. It is not just a way to reduce the fog of war on our side or thicken it on the enemy’s side. It is not analysis of yesterday’s events, although proper application of historical analysis is important to gaining information dominance. It is something that is battled for, like air superiority. It is a way of increasing our capabilities by using that information to make right decisions, (and) apply them faster than the enemy can. It is a way to alter the enemy’s entire perception of reality. It is a method of using all information at our disposal to predict (and affect) what happens tomorrow before the enemy even jumps out of bed and thinks about what to do today. (Johnson, 1994:56)

The key is in how the information is used—what process it is put through in order to obtain a desired output. Until very recently, the main focus was placed on the *efficiency* of the information life cycle. The “wheel” in Figure 6 shows the steps in the information life cycle; creation or acquisition, processing or management, storage, use, and disposal of information. The epitome of success was technology which could move information through the cycle faster or cheaper. Organizations are now beginning to realize that they must consider the processes through which information passes in order to produce an output of value. Otherwise, the cost of information may be reduced, but information will not produce value to justify its cost. Heminger (1997) proposes a model of the information life cycle, combining the cost cycle (measure of efficiency) with the

organization's processes (measure of effectiveness). An organization must combine information efficiency and effectiveness in order to achieve information superiority.

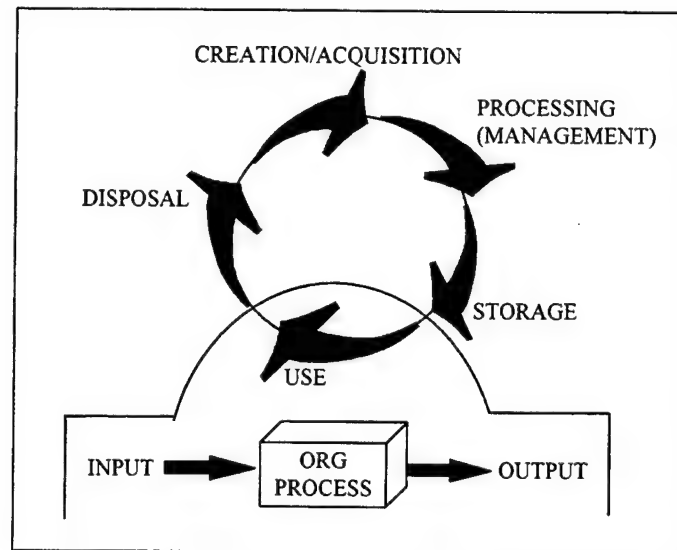


Figure 6. Information Life Cycle (Heminger, 1997)

Information superiority is a slippery concept; it is generally defined in terms of enabling its possessors to take particular actions or attain certain goals rather than as an accomplished state. While information superiority is an Air Force core concept and a military necessity, its main value lies in its integration with strategic, tactical, and operational concepts—this synergy is what will win the war. Lt Gen Douglas D. Bucholz states information superiority is integral to the four essential concepts of dominant maneuver, precision engagement, focused logistics and full dimensional protection presented in Joint Vision 2010; these concepts cannot be achieved unless “we in the information business can implement the operational concept of information superiority” (Ackerman, 1997:n. pag.).

The nature of information makes information superiority different from other types of advantages—information can be held by more than one side at the same time, unlike land, air, sea, space, or physical resources. It is the use of information that allows “superiority” in the information arena, and this advantage is not as easy to maintain; it requires constant monitoring and maneuvering. Information superiority is not equivalent to success, but it is a tool necessary to the attainment of success. Possession of information superiority is of no use if it is not accompanied by victory in conflict or the accomplishment of desired goals.

Activities Associated with Information Superiority. Information superiority may be achieved through four principal areas of activity: construction of an information battlespace or infosphere, protection of that infosphere, gathering and processing (including dissemination) of information, and attack on an enemy’s infosphere and his command and control (Link, 1995; Johnson, 1994). Of these four main activities, direct attack is the only one which cannot be undertaken outside an active war. Intelligence gathering and direct attack are ancient concepts which have been expanded by our relatively recent recognition of the importance of information and our ability to leverage information through the use of technology. Intelligence functions are now able to gather, process, and disseminate more data more quickly by using communications technology, satellites, and computers. Battle plans now call for attacks on information and communications infrastructure, rather than being limited to strikes on transportation and physical resources such as munitions, although information technology also allows for more precise and synchronized attacks. Still, these two activities have merely been

augmented, not fundamentally changed. The newer activities of constructing and protecting an infosphere are the catalysts leading to *information* superiority.

Construction and protection of an infosphere must be done at the strategic level in order to provide a basis for tactical and operational leveraging of information. Although strategic information superiority does not assure tactical or operational information dominance, the strategic infrastructure provides a foundation allowing the commander to construct and dominate the infosphere around the battlespace. This infrastructure supports the commander by providing access to information, enhancing situational awareness, and supplying communications to other areas. Protection of the infosphere must also be considered at the strategic level, although it must be supported at tactical and operational levels through such means as OPSEC, COMSEC, COMPUSEC, and guarding against viruses. Construction and protection of the infosphere at the tactical and operational level lies in the effective and efficient use of existing information technology and the information gained thereby. Activities required to construct the strategic information infrastructure are much more complex. Planning and management of information systems and architectures are basic requirements, but those who perform these activities must be adaptable to the ever-changing technological environment. Information technology must be fully exploited and extended to all areas, but it must also remain flexible and able to respond to changing requirements.

The war fighter in the 21st century must have unequivocal situational awareness. Such capability demands information dominance in the battle space and secure, reliable, and timely availability of all-source information for decision making. Exploitation and optimization of information technology are paramount to achieving this dominance, and information operations will be the vehicle to

achieve and sustain that purpose. Integrated, interoperable C⁴I systems are the tools required, and effective pursuit of such objectives requires dynamic plans and policies to chart the course, architectures and standards to establish the framework, people and partnerships to form the team, and resource management to provide the capability to integrate new information technologies throughout the Air Force and the joint community...Information dominance is the goal—information technology is the weapon—integrated, interoperable C⁴I systems are the means. (C⁴I Horizon 95: A Vision For the Future)

The development and exploitation of information systems as a means to achieving information superiority must be tempered with an understanding of information as an input to a process. Information as well as information technology must be managed both efficiently and effectively, as shown in Figure 6. This is reflected in Emmett Paige's remarks on information superiority.

We must strive for information superiority over any opponent through more rapid gathering, assimilation and transmission of data...In a conflict situation, timing and accuracy of information are paramount. The ability to transmit and receive information consistently and accurately means the difference between success or failure...[however,] the sheer volume of information is something that can interfere with the commander's ability to use it. Achieving true information superiority must involve the ability to distill germane information from an avalanche of data. We will not have produced and delivered quality information for our warfighters, unless it is what they need, when they need it and in a form that they can immediately use. (Paige, 1996:n. pag.)

Information technology is an integral requirement to the attainment of information superiority in today's world. IT can allow us to collect, process, use, and transmit information far more quickly, if properly used.

Information Warfare. Information warfare has recently received a great deal of attention in the high echelons of the military and even in the civilian world. Although the Air Force considers IW as a means of attaining information superiority, the concept of

information warfare is discussed much more extensively than that of *information superiority*. The idea has captured the popular imagination along with the thoughts of military officials; articles about IW appear in military journals as well as popular news magazines. Ideas as to what IW actually is or means are enormously varied, as are the categorizations used to describe IW (DAF, 1995a; DAF, 1995b; Dishong, 1994; Garigue, 1997; Johnson, 1994; Hayes and Wheatley, 1996; Libicki, 1995; Schwartz, 1996; Stein, 1995; Toffler, 1993).

Two of the original proponents of IW are Alvin and Heidi Toffler, visionary authors who wrote of the impact of information technology on the world in their book *Future Shock*, published in 1970. In 1993, they published *War and Anti-War: Survival at the Dawn of the Twenty-First Century*, their vision of how information technology is changing warfare. Although they do not set forth a concise, explicit definition of IW, they present a detailed view of the new wave of warfare. The central theme of this book is the Toffler's assertion that the way we make war is a reflection of the way we generate wealth. The Tofflers suggest that there are successive waves of change in human history, the first wave being the agricultural revolution thousands of years ago and the second the industrial revolution. The third wave is now breaking upon us; the Tofflers argue that we are in the midst of a revolution based on information. They maintain that this third wave is changing all facets of our civilization, including the economy, media, education, and warfare. The Tofflers term this new kind of war *Third Wave warfare*, noting, however, that this type of warfare is still in a rudimentary form. They deliberately stay away from nomenclature such as *information age* and *digital* or *computer age*, to highlight the fact

that these are fundamental changes, not merely changes in the way we use information and information technology. Without using the jargon and buzzwords prevalent in circles where IW is discussed, Alvin and Heidi Toffler present perhaps the best way to classify the functions needed in this new type of war. We have taken the first step by recognizing information or knowledge as a strategic resource, but in order to move this class of warfare toward maturity, we must formulate a workable knowledge strategy. The Tofflers identify four required functions which must be performed in regard to information; the military must "acquire, process, distribute, and protect information, while selectively denying or distributing it to its adversaries and/or allies" (Toffler, 1993:142).

Another well-known author in the IW field, Winn Schwartau, presents this clipped definition: information warfare is "the use of information and information systems as both weapons and targets in a conflict" (Schwartau, 1996:12). Schwartau divides information warfare into three classes; Class 1, personal information warfare, Class 2, corporate information warfare, and Class 3, global information warfare. Following are general examples of each of these classes. Personal information warfare involves intruding on or attacking an individual's electronic records and digital information. The premise is that personal information about each of us is located in many databases, and much of this private information can be legally obtained while the rest can be acquired with minor effort. In addition to stealing from individuals, information warriors can use personal information warfare to leverage changes in society by inserting derogatory electronic information about individuals with whom they

disagree. Corporate information warfare deals with conflict and competition in the economic realm. It includes industrial espionage, stealing technological and commercial secrets from companies in order to secure a competitive advantage. Economic espionage, analyzing financial trends or using insider information, can shift economic spheres in a similar manner. Schwartz meshes these ideas somewhat with his concept of global information warfare, suggesting that foreign companies consistently spy out and steal American technology and attempt to exploit financial information to achieve an economic advantage. The prevalence of connected information systems has only made this easier to do. Analogous to personal information warfare is the corporate information warrior's ability to discredit a company by inserting unfavorable information, or damage it by releasing private information. Class 3, global information warfare, is most applicable to military concerns. It is directed against industries, political spheres of influence, global economic forces, or nations. Class 3 information warfare builds on the power of Class 1 and Class 2 information warfare, victimizing individuals, companies, economies, and nations. It can be focused to attain specific results or spread out for maximum impact; it is cyberterrorism at its worst. Schwartz envisions an "Information Army" under the command of a C⁴I (command, control, communications, computers, and intelligence) group. Others have accepted and built on Schwartz's ideas (Berkowitz, 1995; Braunberg, 1996; Hayes and Wheatley, 1996), mainly focusing on the idea that information is both a weapon and a target, and the thought that information technology used for military advantage is an important consideration in information warfare.

The military and government agencies have their own definitions and classifications of IW. The DoD's definition focuses on broad-based activities:

Actions taken to achieve information superiority by affecting adversary information, information-based processes, information systems, and computer-based networks while leveraging and defending one's own information, information-based processes, information systems, and computer-based networks. (DoD, 1997:n. pag.)

This definition has been refined to specify actions taken "during times of crisis or conflict to achieve or promote specific objectives over a specific adversary or adversaries." (HQ ACC, 1997) The definition is understood to be concerned only with military information and systems, while information superiority is meant to provide a military advantage. The Air Force has a similar unclassified definition.

Any action to deny, exploit, corrupt, or destroy the enemy's information and its functions; protecting ourselves against those actions; and exploiting our own military information functions. (DAF, 1995a)

The military taxonomy is simple; it is effectively the same classification used for any other military operations—offensive and defensive. Specific actions of information warfare are not as clear. Offensive information warfare is generally considered to involve attacks on an enemy's information systems and command structure, but some consider psychological operations and intelligence operations as part of offensive information warfare (Libicki, 1995). Some consider information warfare to be closely allied to command and control, while others claim it has a much wider scope (Hutcherson, 1994; Libicki, 1995). Defensive information warfare is concerned with identifying and protecting vulnerabilities in information systems. Its main focus is on ensuring the

security of information systems through restricting access, encryption, and sometimes physical means such as shielding emanations.

An earlier Air Force definition shows distinct similarities to the taxonomy proposed by Schwartz (1996). Hutcherson (1994) calls information warfare

Actions taken to create an information gap [information superiority] in which we possess a superior understanding of a potential adversary's political, economic, military, and social/cultural strengths, vulnerabilities, and interdependencies. (Hutcherson, 1994:53)

Yet another government definition is proffered by the Central Intelligence Agency (CIA), which states information warfare consists of "unauthorized penetrations and/or manipulation of telecommunications and computer network systems" (CIA, 1997:n. pag.). The CIA is not solely concerned with military functions, although military concerns are included; this perspective focuses on the areas which are threatened by information warfare. Information warfare may be employed against the domestic infrastructure, power plants, air traffic control, financial institutions, or any organization, government or private sector, which tries to ensure the domestic tranquillity and happiness of the country's citizens. Information warfare may also target international commerce, transportation, or communications. This may be a major threat given today's global economy, not to mention the tenuous state of affairs in some volatile sections of the world and the complex interactions between allied nations. Finally, information warfare is a threat to military forces, not only in wartime, but also during times of peace and perhaps especially while performing military operations other than war. With sufficient expertise and knowledge, information warfare can be aimed directly at the

military command and control structure, effectively paralyzing our military force (CIA, 1997).

Martin Libicki of the Institute for National Strategic Studies presents an intriguing view of information warfare, suggesting it may not be possible or even necessary to design a good definition of information warfare. He implies that the plethora of definitions hints there is little that is *not* information warfare. Libicki likens the struggle to define the concept of information warfare to the blind men's attempt to divine the nature of an elephant (the one who touched its trunk said it was like a snake, another who felt the leg insisted the elephant was like a tree, etc.). Nevertheless, he presents a collage of forms of information warfare, indicating that information warfare may better be considered a synthesis of other forms of warfare: command and control warfare, intelligence-based warfare, electronic warfare, psychological warfare, hacker warfare, economic information warfare, and cyberwarfare (Libicki, 1995).

Information warfare is not exclusively an American concept. An article by Timothy L. Thomas published in *Air Chronicles* explores some "unofficial" Russian views of information warfare or *informatsionnoye protivoborstbo*. Thomas notes that the Russian Ministry of Defense has not disclosed a definition of information warfare, but he presents the two most authoritative definitions he gleaned from interviews with Russian military officers. One definition is similar to the United States military assessment; it is an operational-strategic view focusing on offensive and defensive aspects. The taxonomy evident from this definition includes C⁴I, electronic warfare, and deception tactics. The second definition begins by simply stating, "Information warfare is a way of resolving a

conflict between opposing sides.” Interestingly, the author of this definition divides information warfare into two categories, stating that an advantage in information warfare must be gained through both psychological and technical influence. The targets are the same for both categories, but the psychological “weapons” aim primarily at the enemy’s decision-making system and population, while the technical pressures are applied to the enemy’s control system and information resource structures. This second definition includes a caveat that the conflict is resolved through information warfare “with the help of additional means, such as nuclear assets, weapons and electronic assets” (Thomas, 1997:n. pag.). According to Garigue (1996), Russian Military Doctrine has always included the notion of information weapons: a fusion of advanced command and control, communications, intelligence, and psychological and electronic warfare.

Activities Associated with Information Warfare. From examining the various definitions of IW, we can extract numerous activities associated with this idea; in fact, these definitions seem to be primarily concerned with information- and information technology-related activities. Exploitation of our own information resources is a primary requirement, and in order to be leveraged, information must be acquired, processed, and disseminated. On the other side, we want to deny the enemy the chance to exploit his information; therefore, targeting an adversary’s information systems is another important need. A major activity comprising nearly the whole of defensive information warfare is protection of information. As with information superiority, the strategic information infrastructure is of prime importance; it must be in place to support tactical and operational IW. The activities discussed in connection with building an information

infrastructure should therefore also be considered. Information warfare activities align closely with those associated with information superiority, appropriately so, as some form of information superiority is usually seen as a major goal of information warfare.

Information Operations. The term *information operations* has garnered less attention than *information warfare*. These two terms are often used interchangeably; information operations is effectively the peacetime side of information warfare, but since the focus is usually on aggressive acts of information exploitation or denial, many use the term information warfare as a generic description of active leveraging of information and information technology. The most prevalent view is that information operations is any action involving the acquisition, transmission, storage, or transformation of information that enhances the employment of military operations (DAF, 1995a; Cooper, 1995). This definition can be related back to Figure 6; its main focus is on the “wheel” of efficiency, but it recognizes the effectiveness side by insisting that the activities must be of value to military operations.

The U.S. Army presents an in-depth discussion of information operations in chapter 7 of its FM 34-1, Intelligence and Electronic Warfare Operations. According to FM 34-1, “Information operations are the way the Army will prepare and execute knowledge-based warfare across the full range of military operations” (Link, 1995:n. pag.). Intelligence and electronic warfare (IEW) and command and control (C²) warfare are seen as key parts of information operations. This underscores the fact that information is essential to all other resources and activities. A more recent draft

document shows the Army continues to place more value on information; this draft brochure dated 22 January 1997 states:

Information Operations include all measures, both offensive and defensive, taken to achieve information dominance...[IO are] Continuous military operations within the military information environment that enable, enhance, and protect the friendly force's ability to collect, process, and act on information to achieve an advantage across the full range of military operations. Information Operations include interacting with the global information environment and exploiting or denying an adversary's information and decision capabilities. (DA, 1997)

The Air Force also recognizes the importance of information operations; the former Air Force Chief of Staff, General Ronald Fogleman, called information operations "the fifth dimension of warfare" (Fogleman, 1995:n. pag.). However, in contrast to the Army, several Air Force sources distinguish between information warfare and information operations by considering information operations a subset of information warfare. In this view, information operations deals exclusively with the use of military information functions how data is gathered, manipulated, and fused. It is comprised of functions such as intelligence, surveillance, reconnaissance, command and control, communications, precision navigation, and weather, but does not include actions to deny, corrupt, or destroy the enemy's information or efforts to protect ourselves against those actions (DAF, 1995a; Murphy, et. al., 1996).

While the Army considers information operations as a means to execute knowledge warfare across the entire spectrum of military operations, these Air Force sources view information warfare the overriding concept. Information operations is only a subsidiary function, as shown in Figure 7.

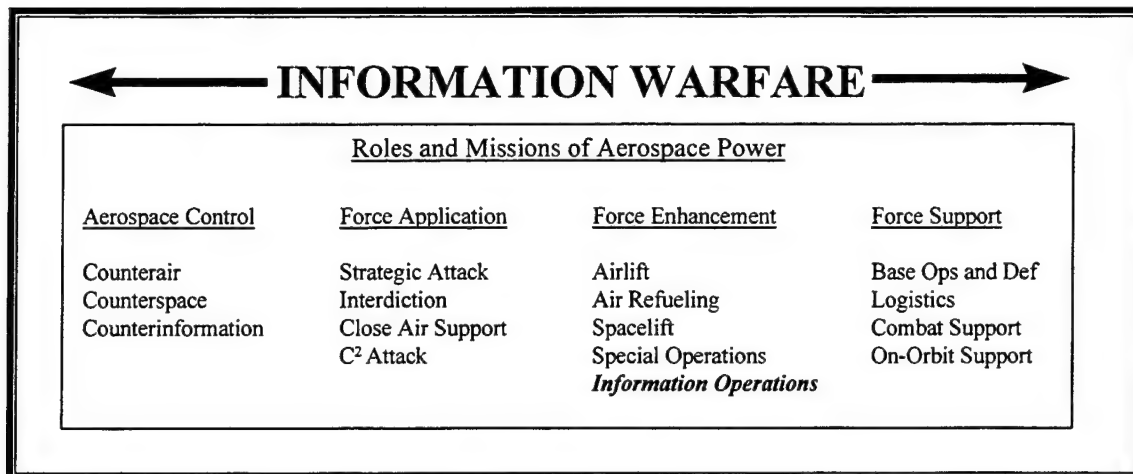


Figure 7. Role of Information Operations in “Wisdom Warfare” (Murphy, et. al., 1996)

The Air Force may be starting to take a broader view of information operations, as evidenced in a 1997 message from Headquarters Air Combat Command (HQ ACC).

According to this message, ACC plans to use the definitions presented in DoD Directive 3600.1, Information Operations; to wit:

IO is defined as “actions taken to affect adversary information and information systems while defending one's own information and information systems.” IW is defined as “IO conducted during time of crisis or conflict to achieve or promote specific objectives over [a] specific adversary or adversaries.” (HQ ACC, 1997)

Activities Associated with Information Operations. As noted with the definitions of IW, the definitions of information operations are principally focused on activities. The activities associated with IO are in general the same as those associated with IW: attacking an enemy’s information systems and defending our own; acquiring, processing, transmitting, exploiting, and protecting our information, while preventing an enemy from doing the same; and constructing an information infrastructure in which to perform information operations. Once again, the U.S. Army provides the best specifics regarding

activities concomitant with information operations: “Activities to support IO include acquiring, using, protecting, managing, exploiting and denying command, control, communications, computer and intelligence (C⁴I) systems” (DA, 1997:n. pag.). The Army notes three interrelated components of IO—relevant information and intelligence, information systems, and operations. All IO activities take place within this sphere, portrayed in Figure 8.

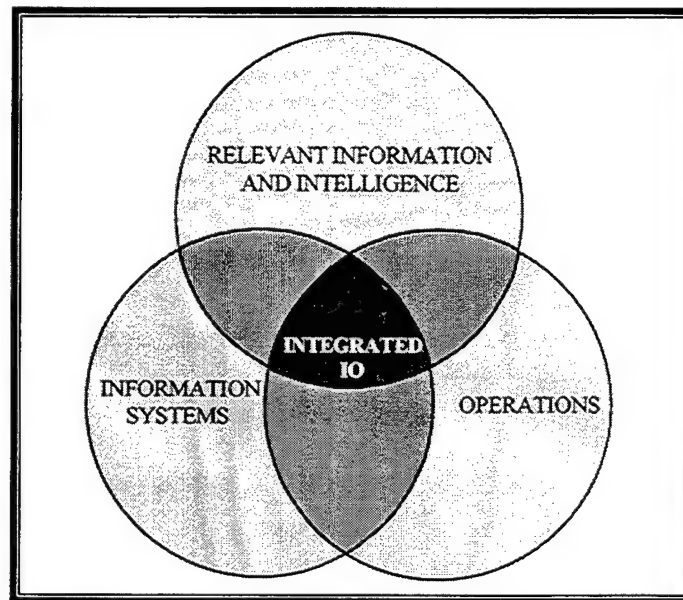


Figure 8. Army View of Interrelated Components of Information Operations (from DA, 1997)

As with IW, IO activities are concerned with achieving information superiority in order to attain final victory.

Examination of Information Concepts. The literature review examined each of the information concepts in order to gain an understanding in terms of the focus, objectives, and approach, thereby suggesting an answer to research question 1:

What are information superiority, information warfare, and information operations, and how do these concepts correlate?

The following tables present the information distilled from a review of the literature surrounding each item.

Table 3. Information Superiority

Focus	Objectives	Approach
<ul style="list-style-type: none"> • Information • Information systems • Decision makers 	<ul style="list-style-type: none"> • Operational or competitive advantage • Understanding information in context of our purpose • Better decision making • Dominant battlefield awareness • Common battlespace picture 	<ul style="list-style-type: none"> • Construct infosphere • Gather, process, and transmit information • Protect information from and deny it to our enemy • Ensure interoperable systems • Plan and manage information systems and architectures

Table 4. Information Warfare

Focus	Objectives	Approach
<ul style="list-style-type: none"> • Information • Information systems • Decision makers 	<ul style="list-style-type: none"> • Information superiority • Attain specified military objectives • Protection of national infrastructure • Better decision making • Better command and control 	<ul style="list-style-type: none"> • Acquire, process, distribute, and protect information • Exploit and defend information and information systems • Attack, deny, or corrupt enemy's information and information systems • Technical or psychological attack

Table 5. Information Operations

Focus	Objectives	Approach
<ul style="list-style-type: none"> • Information • Information systems • Decision makers 	<ul style="list-style-type: none"> • Information superiority • Better decision making • Advantage in all realms of military operations 	<ul style="list-style-type: none"> • Acquire, process, distribute, and store information • Construct infosphere • Interact with global information environment • Protect information and information systems

The focus, objectives, and approach of all these concepts are understandably similar. Each concept centers around information, information systems, and decision makers (the people who use the information and systems). The objectives are to gain some sort of advantage grounded in the use of information and systems by decision makers, while the approaches embody the activities through which the objectives are attained. Differences between the concepts are concentrated in the objectives and approach. Information superiority seems to be an objective in itself; however, information superiority is also a means by which other objectives (operational and strategic advantage or success in an endeavor) are achieved. Information warfare and information operations are intended to assist in procuring success, but they do so by enabling information superiority. Information superiority may therefore be viewed as resulting from the approach activities of information warfare and information operations. The other noteworthy distinction is between information warfare and information operations. Although information warfare is often used generically to describe activities surrounding the exploitation of information, it is better to differentiate between the two concepts in terms of the purposes they serve. The activities are essentially the same, but they are activities which are needed in peacetime as well as wartime. This sort of distinction is made with other types of military operations; for example, air operations activities are conducted in peacetime and for OOTW, but in wartime the same activities are transmogrified into air warfare.

Proposed Definitions. Based on a review and analysis of the literature, the following definitions are proposed as answers to the first research question.

Answer 1a. What is Information Superiority?

Know your enemy and know yourself; in a hundred battles, you will never be defeated.

Sun Tzu—The Art of War

It is difficult to know yourself if you do not know others.

Myamoto Mushaski—Book of Five Rings

Nam et ipsa scientia potestas est. (Knowledge is power.)

Francis Bacon

Information superiority is not an end in itself; it must be viewed as an asset to achieving success in a specified venture. Nonetheless, it is not really an activity directed toward achieving a goal. Instead, it is an aspect of success, the culmination of activities undertaken to achieve an advantage in the information arena. Accordingly:

Information superiority is the information advantage required for success in an endeavor, embodying enhanced decision making and a shared information picture achieved by means of information warfare and/or information operations activities.

Figure 9 shows the role of information superiority in successful military operations (victory in warfare).

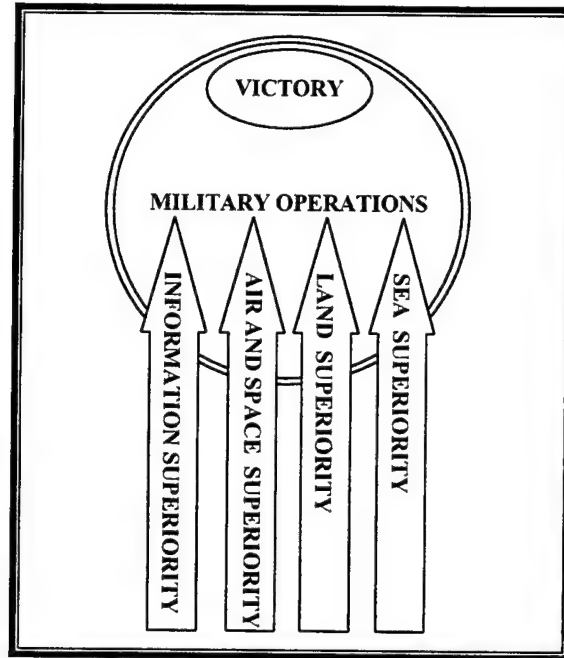


Figure 9. Role of Information Superiority

Answer 1b. What is Information Warfare?

Information is the key to successful military operations; strategically, operationally, tactically, and technically. From war to OOTW, the adversary who wins the Information War prevails.

General (Ret) Glenn Otis, 1991

Information warfare is the most nebulous of the three concepts, perhaps because it is the one which has become a popular notion. The more serious studies and discussions of information warfare generally founder on the question of where information warfare fits in with other types of warfare, or if it is a separate method of warfare at all. One way to clarify the idea is to distinguish between information use in warfare versus information warfare. Information is a strategic resource for all types of warfare, but if information warfare is defined as all conflicts in which information is used, the definition becomes too broad to be meaningful. While some definitions of information warfare include all

actions taken against information or information systems, including such things as bombing information targets, this is not indisputably information warfare; rather, it is conventional warfare that targets information resources. Although venerable activities such as intelligence and psychological operations (PSYOPS) are related to the ideas of information warfare, these are really separate functions that make heavy use of information as a resource. The main difference in warfare and the world today is the advances in information technology and data transmission and sharing capabilities, which have caused information to be viewed as a strategic resource. Since information technology is driving this change, it is appropriate to specify information technology in defining information warfare, as long as the relationships to other types of warfare are recognized. Areas such as intelligence warfare and PSYOPS already have their own niches and functional breakdowns. Information warfare should have its own niche focusing on the capabilities of information technology. Therefore:

Information warfare is the approach to attaining information superiority during times of war, conflict, or crisis contingency by acquiring, processing, distributing, targeting, and defending information resources through the use of information technology.

Since information warfare is an approach comprised of several activities directed toward a goal, it is worthwhile to look at the activities from a process viewpoint. Figure 10 presents a proposed taxonomy of information warfare which retains the offensive and defensive aspects of information warfare, but includes the processes of information flow, information targeting, and information protection.

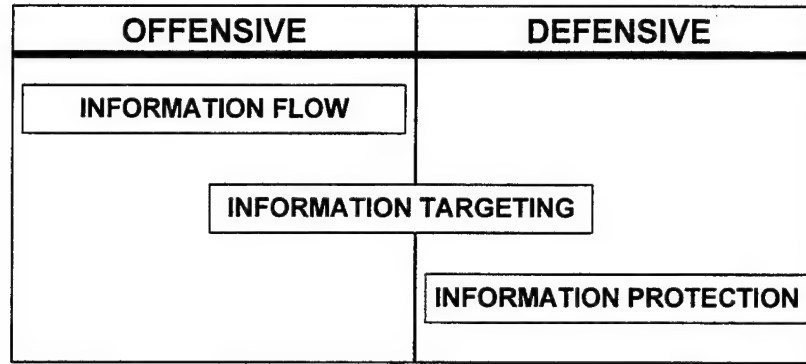


Figure 10. Proposed Taxonomy of Information Warfare

On the offensive side, one process involves the activities of acquisition, management, and distribution. In this process, the input is data and the output is information of value to the user (the commander or warfighter). Another process which should be included in information warfare involves targeting the information systems of the enemy. An input of this process could be part of the information received from the acquisition-management-distribution process; the outcome would be disruption of an adversary's acquisition-management-distribution process resulting in denial of necessary valuable information to the enemy. Both offensive and defensive aspects are encompassed in this process. Disrupting the enemy's information flow is an attack, while damaging an enemy's information technology is one way to defend our own from invasion. The defensive side of information warfare is most concerned with protection of our information and information systems. A defensive process is harder to extract, but defensive information warfare should include measures such as encryption and controlled access. The defensive process can be viewed as an inverted offensive process, where the purpose is to deny the output to the enemy rather than provide it to a "customer."

Answer 1c. What is Information Operations?

Dominating the information spectrum is as critical to conflict now as occupying the land or controlling the air has been in the past.

General Ronald Fogleman

Information operations encompass all information activities performed by an organization. Information must be collected, manipulated, and disseminated in order to conduct the day-to-day functioning of any organization, not just to promote the chances of success in conflict and crisis. Like information warfare, a major component of information operations is information technology. However, information operations should also incorporate principles of managing information across all organization operations, in order to ensure that when a crisis arises, the activities required for victory in information warfare have been internalized and the infrastructure necessary for successful employment of these activities is in place. Consequently:

Information operations are actions taken within the information environment in order to achieve and maintain information superiority. These actions include: collection, processing, dissemination, and protection of information; planning and designing information technology to ensure ability to perform these activities; and construction and maintenance of the information infrastructure in which operations are executed.

Figure 11 portrays the sphere of information operations.

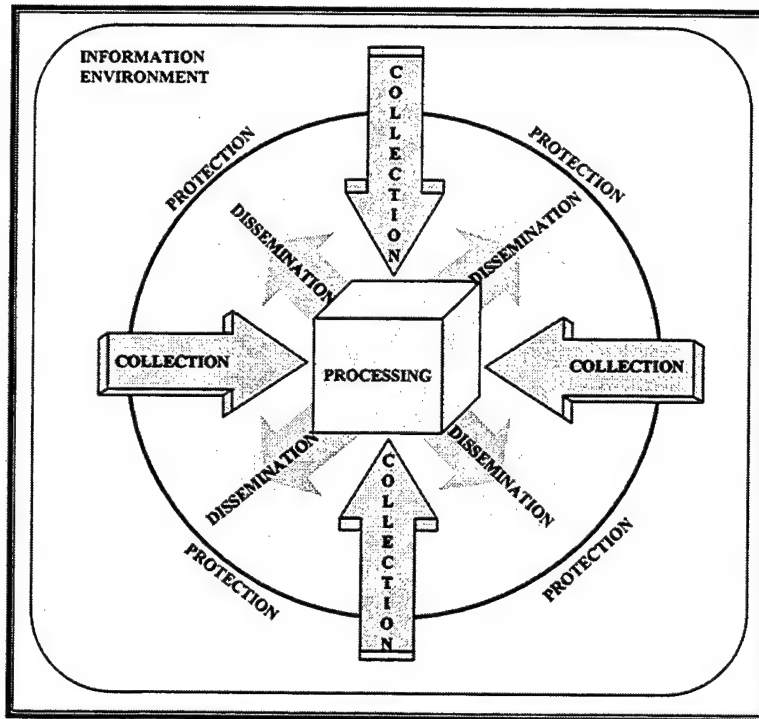


Figure 11. Information Operations

Answer 1d. How do Information Superiority, IW and IO relate?

Implicit in the definitions of these concepts are the relationships between them. If information superiority is a support for successful operations, IW and IO activities are the support for information superiority. The activities inherent in information superiority are derived from those encompassed in the broader activities of information warfare and information operations. In effect, IW and IO are the embodiment of the activities which support the overarching goal of information superiority. The information operations activities dealing with construction of the infosphere and management of information activities, resources and systems form the basis for the activities inherent in information warfare. The activities of collection, processing, use, and transmission, while intrinsically the same in IO and IW, acquire more urgency in times of conflict. These

activities and the information technology supporting them should be in place and operationalized in order to ensure a smooth transition to IW in times of crisis.

Decision Making Theory. One of the primary focus areas in information superiority, IW, and IO is decision makers. Decision making has long been recognized as one of the key elements of management (Browne, 1993; Calhoun, 1991; Eden and Harris, 1975; Griffin, 1996). Simply, “decision making is a process by which a person, group, or organization identifies a choice or judgment to be made, gathers and evaluates information about alternatives, and selects among the alternatives” (Carroll and Johnson, 1990:19). However, the omnipresence of this process in all entities and organizations has spawned numerous theories and models related to the decision making process.

Research has confirmed the idea that there is value in a decision maker being familiar with a particular solution method; in many cases, confidence in the decision increases with familiarity and an understanding of the cognitive structure of decision making (Buchanan, 1994; Yadav and Khazanchi, 1992). Understanding the forces in decision making can assist us in targeting decision processes—one of the goals of IW (Dishong, 1994). This section will examine some of the most preeminent rational decision making models and consolidate the concepts into a rational decision model for use in this study. Note that information (or the lack of it) is considered in each theory; information is invariably considered a vital part of the process of decision making.

Classical Model and Concepts of Uncertainty. The classical model of decision making assumes decision makers are rational, logical, and have “perfect” information, enough to eliminate any uncertainty in the decision. Based on these assumptions,

decision makers should follow a prescriptive approach: obtain complete information to eliminate uncertainty, evaluate all the options rationally and logically, and produce an end result of a decision in the best interests of the organization (Griffin, 1996).

Unfortunately, the assumptions of the classical model are usually not met in the real world, except perhaps for some few structured decision situations. Indeed, in problems involving people and human decisions, the solution is rarely clear cut. In particular, most military decision situations possess a degree of ambiguity and uncertainty or “fuzziness” and are not easily captured in a static or stochastic model. This has led to an increased use of “fuzzy sets” in analyzing decisions, not in an attempt to quantify the unquantifiable, but as a way to formalize our way of dealing with the unquantifiable and imprecise (Binaghi and Rampini, 1993; Dockery, 1979). The concept of fuzziness is related to the idea of the “fog of war” introduced by Carl von Clausewitz. In his discourse *On War*, Clausewitz presents two concepts leading to difficulties in conflict, friction and fog. Friction is the effect of numerous minor incidents which reduce the level of performance so the intended goal is not reached (Clausewitz, 1984). There are physical and psychological aspects of friction. Friction due to a hostile physical environment is usually more obvious; it is caused by darkness; bad weather or terrain; physical exertion; degraded command and control, logistics, maintenance, or weapon systems; or merely chance bad luck; or psychological factors, such as stress produced by the interaction of combatants and the environment of war. Another source of friction is the “fog of war.” Fog is the uncertainty (the fuzziness) of war, caused by factors such as inaccurate, incomplete or contradictory information, deviations in weapon system

efficacy, actions of the enemy, and the enemy's nebulous capabilities and intentions (DAF, 1992). Although a rational decision model is used in this research, it is understood that the operational decision maker usually faces decisions under conditions of uncertainty—intrinsically imprecise decisions under adverse conditions would normally be faced in military operations.

Process Models. Many authors have identified a set of steps taken in the rational decision making process. The underlying premises in these process models are similar, although some authors expand the number of steps taken. Table 5 presents the authors accompanied by the steps they associate with decision making.

Table 6. Authors and Identified Steps in Decision Making

Steps in Decision Making Process	Author
<ul style="list-style-type: none"> • Intelligence (searching environment for conditions requiring a decision and obtaining information regarding the decisions) • Design (determining available courses of action and analyzing respective values) • Choice (selecting an action) 	Simon 1957; Radford, 1978
<ul style="list-style-type: none"> • Recognition of a challenge • Acceptance of the challenge • Meeting the challenge (through a choice) • Committing to the choice • Adhering to the choice 	Janis, 1968
<ul style="list-style-type: none"> • Problem recognition • Problem diagnosis • Action selection 	Schrenk, 1969
<ul style="list-style-type: none"> • Developing a criteria set • Posing criteria questions • Scaling responses • Choosing among alternatives 	Frederikson, 1971

<ul style="list-style-type: none"> • Information gathering • Development of alternatives • Evaluation of alternatives • Choices 	Witte, 1972
<u>3 Phases:</u> <ul style="list-style-type: none"> • Identification of problem • Development of alternatives • Selection of alternative <u>7 central routines in decision process:</u> <ul style="list-style-type: none"> • Decision recognition • Diagnosis • Search • Design (if no ready-made solution found in search) • Screen • Evaluation-Choice • Authorization 	Mintzberg, 1976
<ul style="list-style-type: none"> • Establishment of purpose/goals • Analysis • Synthesis • Implementation 	Miller, 1979
<ul style="list-style-type: none"> • Information collection • Problem analysis • Selection of action alternative • Implementation of decision • Monitoring progress (feedback, modify or override decision) <p><i>(Functions are iterative and overlapping)</i></p>	Modrick, 1979
<ul style="list-style-type: none"> • Recognition • Formulation • Alternative generation • Information search • Evaluation/choice • Action/feedback 	Carroll and Johnson, 1990
<p><i>(Decision similar to action workflow loop)</i></p> <ul style="list-style-type: none"> • Proposal • Agreement • Performance • Satisfaction 	Medina-Mora, Winograd, Flores, and Flores:1992
<ul style="list-style-type: none"> • Identify problem • Search for alternatives • Evaluate alternatives • Choose an alternative 	Browne, 1993

<ul style="list-style-type: none"> • Setting managerial objectives • Searching for alternatives • Comparing and evaluating alternatives • Choosing a course of action • Implementing the decision (added in 1996) • Following up and controlling the decision 	Harrison, 1993, 1996
<ul style="list-style-type: none"> • Recognize and define situation • Identify alternatives • Evaluate alternatives • Select best alternative • Implement chosen alternative • Follow-up and evaluate action 	Griffin, 1996

Each of these models requires information for at least some of its steps: information is gathered about a situation, information is used in generating and assessing alternatives, and/or information is needed to evaluate the situation after a decision has been made.

While there are minor differences in the process steps, there is no disagreement about the fact that information is essential to decision making. Decision making is the end result of a series of cognitive activities revolving around the collection and use of information.

Research supports the notion that people with more complex cognitive structures are better able to integrate acquired information into decision making processes (Streufert et. al., 1965). Studies also suggest that organizations are more efficient when they have a greater effort devoted to information processing (Miller, 1979). It has been proposed that a new model be developed conceptualizing decision making as information processing (Browne, 1993).

Military Models. The military views military decision making, particularly in times of conflict, as intrinsically separate from other arenas of decision making. There are several models of decision making developed specifically for military situations,

although in some cases, these models are embraced by civilian organizations, further spurring the Toffler's philosophy that "the way we make war reflects the way we make wealth" (Toffler, 1993:3).

OODA Loop. One of the most respected military decision making models is the OODA (Observe, Orient, Decide, Act) Loop, developed by the late Col John Boyd as part of his Asymmetric Fast Transient theory of conflict. Boyd's treatise, "A Discourse on Winning and Losing," is considered an important and original military work, on a par with Clausewitz's *On War* and Sun Tzu's *The Art of War*. He is one of the premier military theorists of the twentieth century (Peters, 1991). Boyd's OODA Loop is cited by a number of authors and agencies, often in writing about information warfare and military doctrine (Cooper, 1995; Libicki, 1995; Schectman, 1996; Stein, 1995; Szafranski, 1995), in addition to some noted authors in the civilian sector (Peters, 1991). There are four steps in this decision cycle (these steps have palpable similarities to those in the previously discussed process models):

- *Observe*--gather data from surrounding environment
- *Orient*--create a mental model or mental "map" of the circumstances surrounding the decision, bounding the area within which the decision must be carried out
- *Decide*--make the decision (select an appropriate solution)
- *Act*--implement the decision

Figure 12 is a graphical representation of the loop formed by these steps.

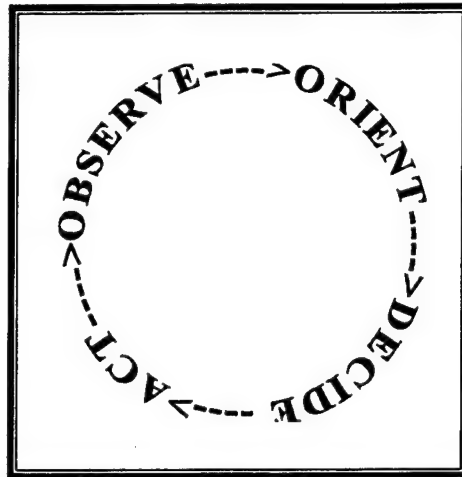


Figure 12. OODA Loop (Boyd, 1987)

In Boyd's theory, the goal is to operate at a faster tempo and proceed through the steps more rapidly than the enemy, constricting the OODA loop until we are operating inside the mind-time-space of our adversary. Battle (or any competitive situation) is a series of time-competitive observation-orientation-decision-action cycles. The side with the smaller OODA loop will triumph (Peters:1991; Smith, 1989). Information is an integral part of the loop, particularly the first two steps. Information gathering is the crux of observation. Better and faster information allows quicker orientation and may increase confidence in the decision, encouraging faster action.

The OODA loop was initially developed as a model to explain dominance in maneuver and tactical situations. The side that can progress through the OODA cycle more rapidly, constricting the loop, will emerge victorious. The OODA loop is analogous to the information life cycle. Moving through the activities of the information life cycle more quickly can result in greater efficiency. Navigating through the OODA cycle more quickly can result in more efficient decisions. However, as shown in the

information life cycle model, effectiveness should not be ignored. In a previous AFIT master's thesis, Captain Greg Schectman developed an augmented OODA loop to depict the tradeoff between quality and speed. He expanded the OODA cycle, including each activity as a subprocess in which the time needed to complete the subprocess is a function of the speed and the quality required. Figure 13 illustrates the possible effects on the overall OODA cycle.

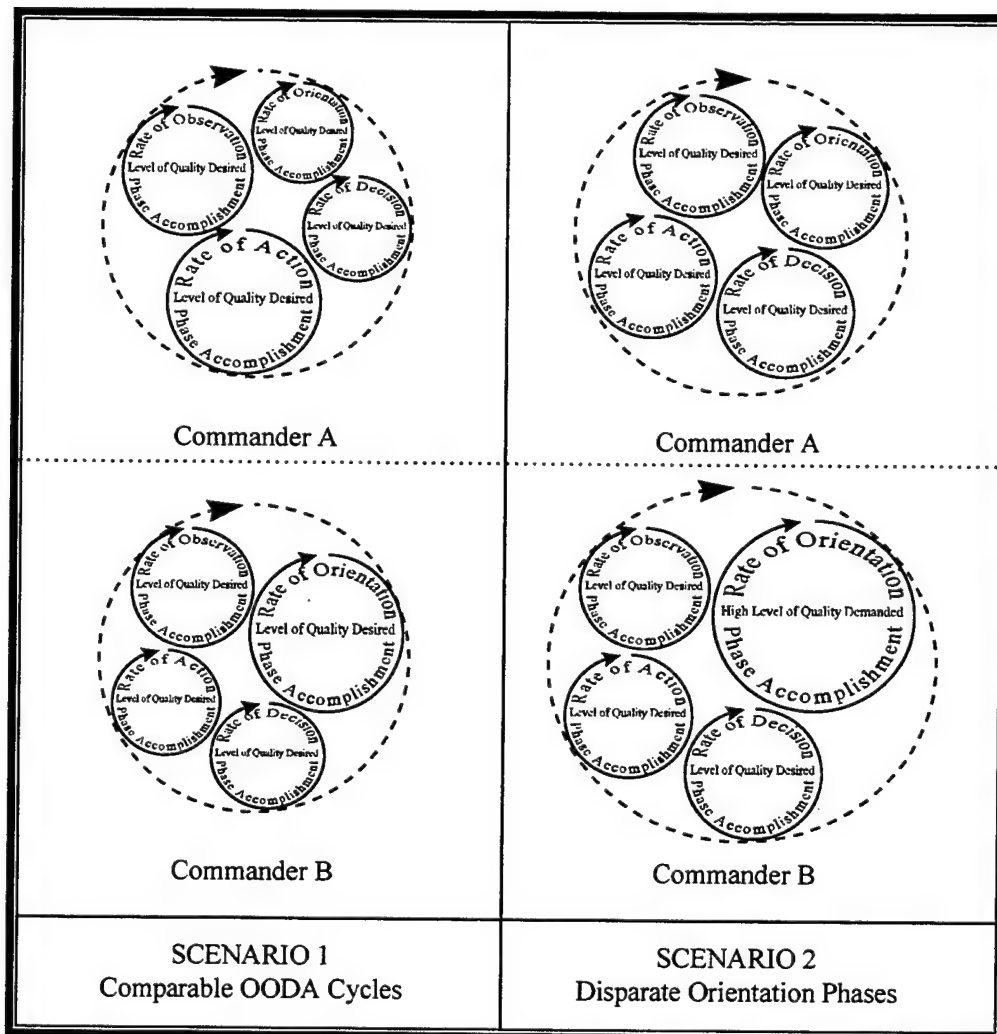


Figure 13. Augmented OODA Loops (Adapted from Schectman, 1996)

In the first scenario, commanders A and B complete the subprocesses at different rates. Commander B's decision phase subcycle is larger, representing the fact that commander B takes significantly longer to decide on a course of action since he desires more information. At this point, his adversary, commander A, is inside commander B's OODA loop. However, in the next phase, commander A's larger action loop indicates he is unable to implement his decision as quickly as commander B. In the end, the disparity between the OODA loops disappears. Although the subcycles were accomplished at different tempos, the time required for the entire process was comparable. In the second situation, the two commanders observe, decide, and act at a nearly identical tempo. However, Commander B uses a significantly larger amount of time pursuing additional information with which to form his mental image and understand the environment, inflating his observe subcycle. This allows Commander A to function inside Commander B's OODA Loop, increasing the probability that Commander A will win the conflict (Schectman, 1996).

Two-Sided Decision Cycle. Some of the same elements are present in an earlier decision cycle model presented by Coe and Dockery. Again, the time response is an significant factor. Coe and Dockery note the importance of noting both sides of the decision cycle in a conflict; it is essential to remember and take into consideration that the enemy is moving through the decision cycle also. They also include an often overlooked factor in the decision cycle—the environment, which mediates all transactions between the opposing sides. Although the internal environment is specific to the decision making organization, the external environment may be the same for both sides. If one side can

gain a measure of control over the external environment, it can gain a corresponding advantage by increasing the fog and friction of the other side. Accurate, timely, and sufficient information can reduce the fog of our side and allow us to manipulate the environment and decision cycle to our advantage (Coe and Dockery, 1988). This two-sided decision cycle is illustrated in Figure 14.

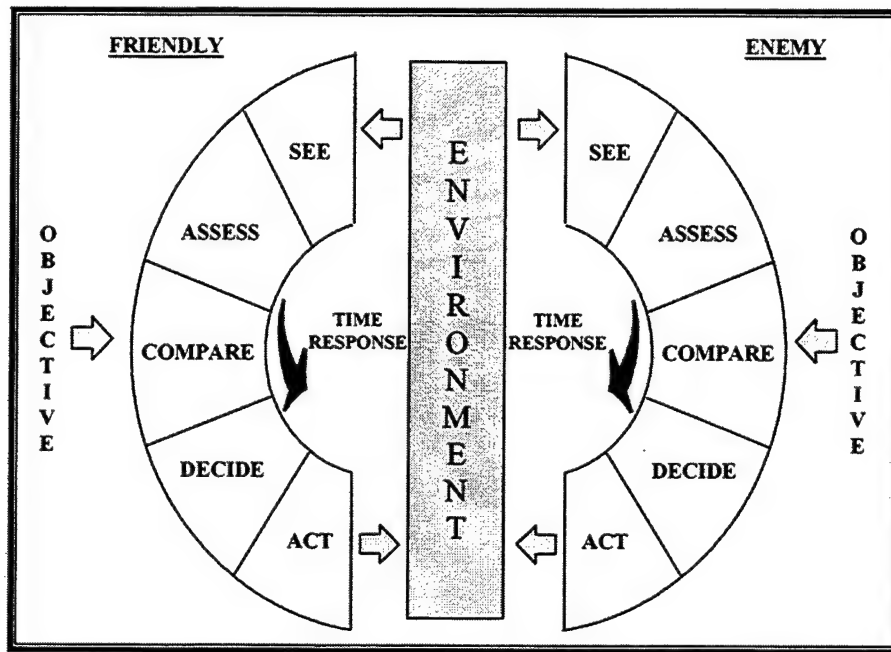


Figure 14. Two-Sided Decision Cycle (Coe and Dockery, 1988:25)

CPEA Model. Another military model is the concept, planning/preparation, execution, and assessment (CPEA) model, part of U.S. Army doctrine in FM 101-5, Command and Control for Commanders and Staffs (Rota, 1996). As can be seen from the name, this is another four-step model including the following four actions:

- Formulate the concept and visualize the task that must be performed
- Plan and prepare the mission
- Execute operations
- Assess the situation (including anticipating effects on future operations)

This model can be used in wartime and in OOTW, a major concern of today's military. The proactive focus provided by the anticipation of future events makes CPEA an ideal model for use in situations, such as OOTW, where a number of events may occur simultaneously or in quick succession, and where time constraints and manpower limitations hinder more deliberate decision making (Rota, 1996). Figure 15 depicts the CPEA model.

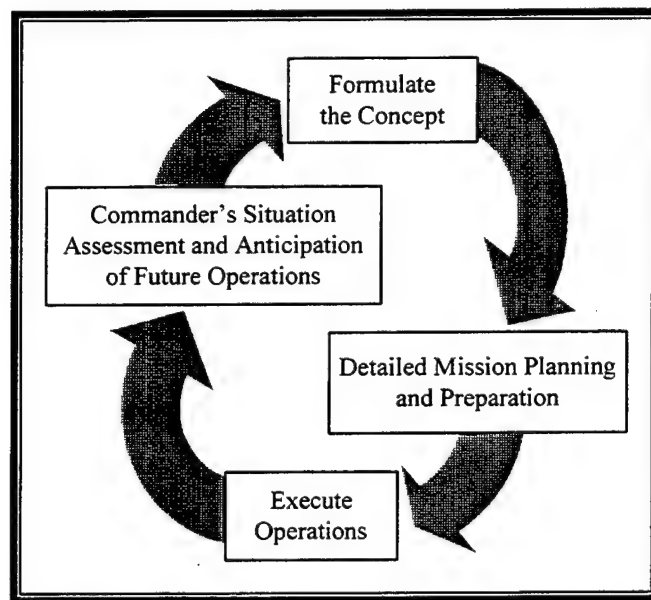


Figure 15. CPEA Model (Rota, 1996:25)

Information is critical for the first step in this cycle; in order to formulate the concept, a decision maker must have an accurate assessment of the current situation. One of the major elements in CPEA doctrine is the commander's critical information requirements (CCIR). Although the actual information products may differ between war and OOTW or between different operations, the activities required to generate the CCIR are the same: information acquisition, assimilation, and evaluation. Information analysis

and distribution are necessary to planning, preparing, and executing the mission (Rota, 1996).

Consolidated Model Used for this Research. All these models comprise essentially the same process, with the steps condensed or augmented depending on the author's perspective. However, few recognize the importance of first acquiring the information to assess, and those that do generally fail to include a step to evaluate the consequences of the decision. The only one that does include both steps (Modrick, 1979) makes no distinction between scanning the environment for recognition of a problem and collecting information once a situation is identified. In addition, only the military models show any indication of constraints, particularly time pressure, imposed by the environment.

Based on a review of the academic literature surrounding decision making, Figure 16 presents a synthesis of these popular process models, including each of the pertinent steps. It borrows from the ideas in Boyd's OODA Loop and Schectman's augmented OODA Loop to depict the time constraints dictated by the wartime environment. The size of the loop around each step denotes the amount of time available for that activity, while the overall loop represents the total amount of time taken for the decision process. The acquisition of information is an ongoing process, comparable to a substep in each activity. Furthermore, the steps in decision making are set in the context of the organization's mission and objectives. The steps presented in accepted decision models are extracted and integrated into a model for use in examining the research problem which is the focus of this thesis.

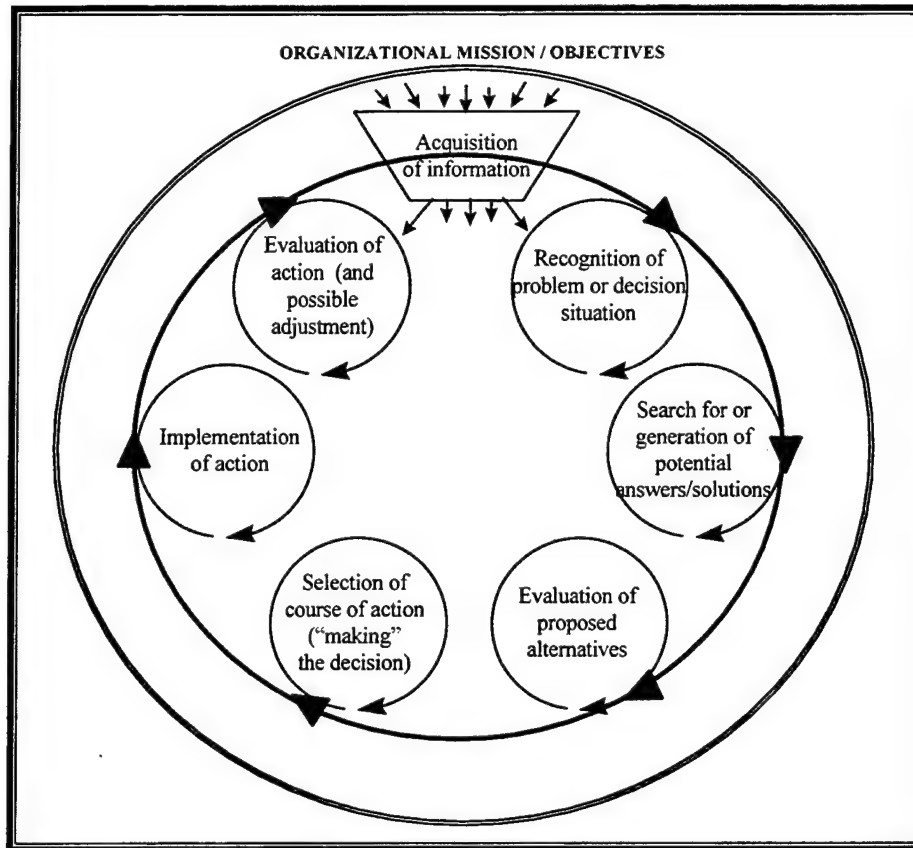


Figure 16. Synthesized Rational Model of Decision Making

For purposes of this study, it will be assumed that a decision maker experiences each of the steps described in the synthesized model.

Limitations. It is important to note some accepted concepts in decision making theory that are not explicitly addressed in most rational decision models. A descriptive model of decision making was developed by Herbert Simon (1957), one of the first researchers to acknowledge that decisions often cannot be made solely through the application of logic. This descriptive model contends that decision makers usually must use incomplete and imperfect information, are constrained by bounded rationality, tend to satisfice, and produce decisions that may or may not be in the best interests of the

organization (Griffin, 1996). The concepts of bounded rationality and satisficing have been recognized and used by a number of other authors. Bounded rationality suggests that decision makers are limited by their personal experiences, values, skills, and unconscious reflexes and habits. They must construct vastly simplified models of reality in order to make decisions. *Satisficing* is the idea that decision makers do not conduct an exhaustive search for alternatives, but instead seek alternatives only until they identify one that meets a minimum standard of acceptability (Campen, 1992; Griffin, 1996; Simon, 1957; Slovic, 1982). Another important concept in decision theory is that of information overload. Any system, organic or organizational, can be presented with more information than it is able to process in the amount of time available. As a consequence of this information overload, performance effectiveness diminishes or breaks down entirely (Browne, 1993; Miller, 1979). Although a rational model is used in this research, these concepts are recognized and propositions developed with consideration for these concerns.

Information Technology

In order to properly present the framework around which to build propositions about the research problem, it is also necessary to define what is meant by *information technology*. Unlike the other elements explored in this research, information technology has been defined by law. The Information Technology Management Reform Act of 1996 (Division E of Public Law 103-62, also known as the Clinger-Cohen Act) defines information technology as follows:

The term "information technology", with respect to an executive agency means any equipment or interconnected system or subsystem of equipment, that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information by the executive agency... The term "information technology" includes computers, ancillary equipment, software, firmware and similar procedures, services (including support services), and related resources. (United States Congress [ITMRA], 1996)

Information technology has also been defined by various researchers who have examined its effects on or use by organizations and individuals. Huber (1990) defines IT as devices that "transmit, manipulate, analyze, or exploit information" or in which "a digital computer processes information integral to the user's communication or decision task" (Huber, 1990:48). Molloy and Schwenk (1995) present a similar definition, stating IT "may be defined as computer-based technology for the storage, accessing, processing, and communication of information" (Molloy and Schwenk, 1995:283). The basic elements of these IT definitions are common to many writers on the subject (Arnold and Killian, 1995; Cheney and Dickson, 1982; Foster and Flynn, 1984). It should be noted that the term is not always specifically defined; often the focus is on the effects of IT, which is understood to be an information processing or communications device. An interesting distinction is made by Calhoun (1991), who separates IT into two types—IT used for communication and IT used for computing or processing information. For purposes of this research, information technology is considered to be devices that support the activities in the information life cycle (see Figure 6), with the specific inclusion of communication as part of the processing activity; it includes: hardware; software;

network and communications connections and equipment; standards, protocols, and interfaces; and support services such as documentation.

There are numerous information technologies being used and developed in the military and in the civilian sector, far too many to examine individually. While there have been some experiments and tests to determine the efficacy of specific information technologies (i.e. the Army's Advanced Warfighting Experiment and the annual Joint Warrior Interoperability Demonstrations) which are used as support for the ideas presented in this thesis, this research is not intended to be an in-depth study of these technologies. Rather, it will propose general principles regarding information technology and its relationship to the activities in decision making and information superiority.

Summary

This chapter examined the components in the conceptual framework delineating this research, defining the associated concepts in order to provide an understanding of each element. It defined the primary area of interest, information superiority, and further explored the terms used in this definition, information warfare and information operations. Information technology was also defined for the purposes of this study. Additionally, process models of decision making were explored, and a model for use in this research was synthesized from this examination.

IV. Analysis

Introduction

This chapter directly addresses the question of how information superiority can be achieved. It examines the data gathered and analyzed throughout this research, with the focus on the data display and conclusion drawing steps of the interactive model of data analysis. The conclusions are presented in the form of a series of propositions surrounding the concept of information superiority. The first two propositions are centered around the development of an information superiority process model, developed using the previous chapter's analysis and definition of information superiority. This model is used as a framework for the other propositions, which explore the idea of how information technology can enhance the achievement of information superiority.

Development of Propositions

The previous chapter defined information superiority in these terms:

***Information superiority** is the information advantage required for success in an endeavor, embodying enhanced decision making and a shared information picture achieved by means of information warfare and/or information operations activities.*

This definition condenses the panoply of activities involved in information superiority into its two related concepts, information warfare and information operations, respectively defined in this research as follows:

***Information warfare** is the approach to attaining information superiority during times of war, conflict, or crisis contingency by acquiring, processing, distributing,*

targeting, and defending information resources through the use of information technology.

Information operations are actions taken within the information environment in order to achieve and maintain information superiority. These actions include: collection, processing, dissemination, and protection of information; planning and designing information technology to ensure ability to perform these activities; and construction and maintenance of the information infrastructure in which operations are executed.

However, in order to examine the methods of attaining information superiority, it is necessary to create a model of the concept which includes the main activities. Since information superiority is considered an “information advantage” achieved as the outcome of certain activities, a process model is needed, showing information superiority as the desired outcome (or valued output) of a process where the input is information. The activities identified as integral to information superiority, IW, and IO are used as the basis for this model, shown in Figure 17.

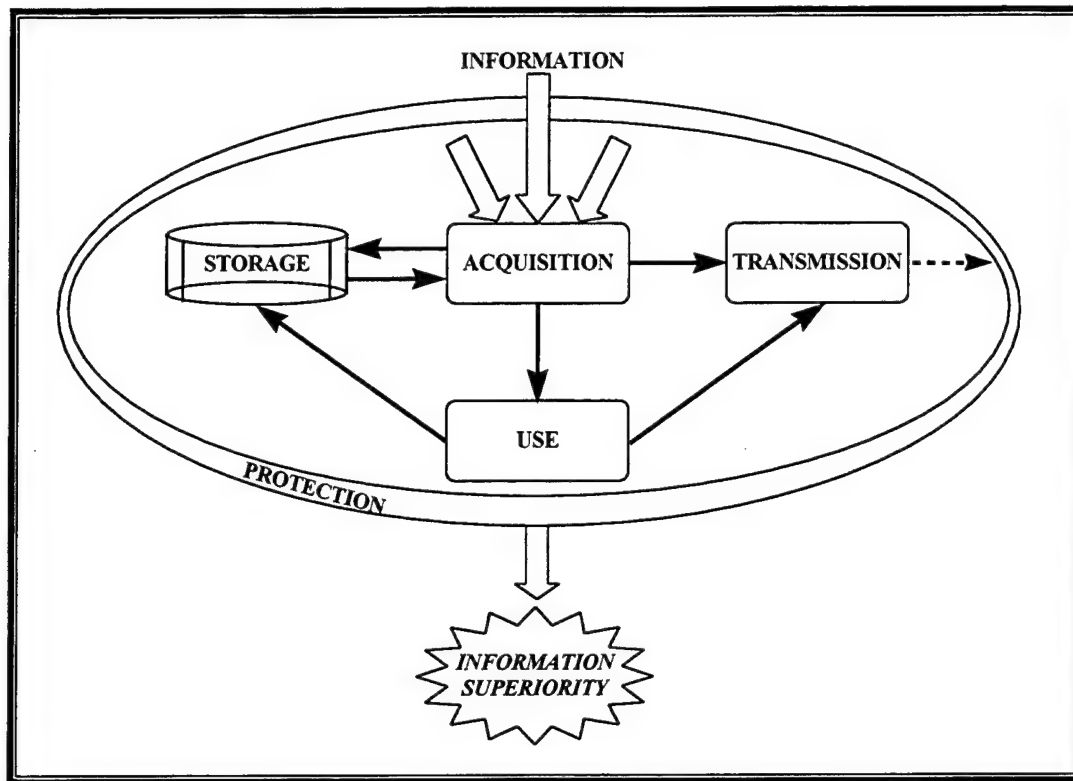


Figure 17. Conceptual Model of Information Superiority

Information is acquired in a number of ways. It may be “created” from inside someone’s head, gathered from the external or internal environment, or received as the result of a transmission from another source. If information is not immediately required for use, it may be stored until a demand arises, and/or distributed to others who need it. The use of information is the purpose of many of the activities of IW and IO; indeed, this is where information is actually transformed into an output of value. Exploitation of information, attack on enemy information (including denial or corruption of that information), targeting, and employment of information in planning or decision making are all activities included in the use function. The remaining major activity, information

protection or defense, is not really an activity that uses information; rather, it is a boundary within which the other activities should transpire.

With the understanding that information superiority is the advantage gained through the activities depicted in the information superiority process model, it is reasonable to assume that:

Proposition 1: Information superiority can be achieved by managing the acquisition, processing, storage, transmission, and use of information more effectively and efficiently than an adversary.

Support for this proposition can be drawn from Chapter III's examination of information superiority and the related concepts of IW and IO. Although the premise of this proposition seems obvious, the idea of a process diagram to model the activities inherent in information superiority is not evident from a review of the pertinent literature. As previously noted, many writers who discuss information superiority do not give a clear definition of the concept, nor do they explicitly specify the activities required; however, the activities apparent in their discussions of information superiority can be extracted. This exercise was performed and the results displayed in Chapter III, where information superiority, IW, and IO were defined. These results were used to develop the information superiority process model and formulate this proposition.

Further support can be derived from accepted resource management theory. "An organization succeeds by bringing together and managing certain resources in a productive way" (Zwass, 1992:15). Much of management theory is centered around ways to use inputs or resources to achieve an organization's goals in an effective and

efficient manner. Of the traditional roles of management (planning, controlling, organizing, and leading), the control function of is the best to associate with resource management, as this function involves the regulation and monitoring of activities to ensure a particular element shows a specified level of performance, in order to provide a measure for goal attainment (Griffin, 1996). Information has been accepted as a resource; like any other type of resource, those who manage it better will reap the benefits. In fact, Griffin states that "it is possible to conceptualize management itself as a series of steps involving the reception, processing, and dissemination of information" (Griffin, 1996: 666). However, information is a unique type of resource. The most notable difference is that information is inexhaustible; it can be used over and over again, or transferred to another for use without losing the ability to use it for oneself. However, especially in a crisis setting (such as wartime), information can be extremely perishable. Information that was good a few moments ago may be of no use now. Recognition of the uniqueness of the information resource has led to the development of the information resource management (IRM) discipline. Campen states that superior management of information should rank high in every list of operational enabling factors (Campen, 1992) Although the activities inherent in management of information resources are essentially the same as those involved in management of other resources, the unique nature of the information resource adds another activity, transmission, to the set of required resource management activities. Since information can be, and often needs to be, used by more than one party at the same time, the ability to disseminate information becomes a critical activity, proved by its prevalence in discussions surrounding information superiority, IW, and IO.

The singular attributes of the information resource also demand a different approach to the activities required for its management. Chief among these activities is acquisition. Information is the only resource not subject to the basic economic problem of scarcity. Although information may be deliberately concealed or withheld, the availability of sufficient information is generally not a limiting factor; in fact, often there is an overabundance of information. Moreover, in the context of decision making as the use process in the information superiority model, information overload caused by overacquisition can have a debilitating effect on information superiority. (Browne, 1993, Rogers, 1987, Modrick, 1979, Landauer, 1995, Garner, 1991, Radford, 1978) The acquisition activity is the means by which the resource enters the pipeline. All the other activities are predicated on the availability of the proper amount and type of the resource. With other types of resources, the activities subsequent to acquisition may have to deal with scarcity and how to allocate resources to best meet goals. In information resource activities, however, there is the possibility of too much information entering the pipeline, compelling the other activities to sort through masses of information or try to force too much through the channel, possibly causing the whole cycle to grind to a halt. Discussions of information superiority and the concomitant IW and IO tend to focus on offensive and defensive aspects and the activities associated with them, such as attack, targeting, and information exploitation, and protection of these activities. While these are important, they can be impeded through our own mismanagement of information acquisition much more readily than by enemy attack. Realization of this possibility led to the development of proposition 2.

Proposition 2: Ensuring the acquisition of only germane information is a requirement for information superiority.

As noted, one glaring deficiency in using the standard resource management activities in striving for information superiority is the omission of a filter for the information entering the cycle. Only a certain amount of information can move through the pipeline; if the cycle is clogged with irrelevant information, the other activities are slowed. The decision making process serves as a useful context in which to view the problem of other activities being hindered because of inappropriate acquisition activities.

The report of a systems analysis conducted for Air Force Materiel Command's Science and Technology Directorate (AFMC/ST) preliminary to the design of a system to manage the Modernization Planning Process (MPP) can be used to illustrate this problem. The AFMC/ST commander needed a tool to capture and share information necessary to the MPP, in order to assist decision makers in setting priorities, responding to fluctuations in funding, and evaluating current and future requirements. During the analysis phase of system development, a number of critical problems emerged. Information necessary to the MPP was stored in several different areas and was not readily available to AFMC/ST. In addition, much of the information provided in response to queries was inconsistent, erroneous, not timely, in an incompatible format, or was simply not the information needed. There was no existing plan to coordinate organizational objectives with a long range information strategy (Morris, et. al, 1997).

Walsh (1997) discusses the problem of too much information, noting that one of the U.S. generals in charge at the time of the 1996 bombing of the dormitory on the base

in Dhahran, Saudi Arabia, was criticized for ignoring intelligence warnings of a possible attack. His rejoinder was that he had not ignored the reports, but had so many of them he was unable to pick out those that would have alerted him to the ultimate problem. With the current technological means to gather massive amounts of information at high speeds, the problem today is usually not that the information is unavailable, but that it is buried. Another danger is that information may be used to justify or make decisions, due to the sheer weight of information about an issue (Walsh, 1997).

Information engineering provides a means to map objectives to activities and the underlying processes. In particular, information strategic planning allows the determination of basic critical processes and the information needed to support those processes. Information strategic planning can act as a filter for the information life cycle, permitting decision makers to focus on accelerating and improving decisions rather than extracting the bits of useful information from a mass of data. Developing principles of IRM are also useful for challenging this issue (Schectman, 1996).

The best way to protect yourself from being buried by the infolanche is to make sure you have specific priorities about what information you need, when you need it, when it should be introduced into the decision-making process, and most important of all, when you have enough. (Walsh, 1997:22)

Data warehousing is another concept which can assist in ensuring that necessary information can be acquired without sorting through a mass of data. This technology entails collecting data from operational environments and storing it in a meaningful and suitable format for the desired use. Gathering information can be viewed in process

terms—what information is needed, where it is stored, how to obtain a consolidated view of the data. Data warehousing technology fits into information engineering methods.

In order to have easily accessible information, you need to have the information designed and organized into a data warehouse, an integrated architecture that is both detailed and summarized, with historical data and something called metadata [data about data] that allows easy discovery of the needed information. (Teresko, 1996:44)

It is apparent from the examination of information superiority from the perspective of its focus, objectives, and approach that while the approach activities focus on attack and defense, the focus is on decision makers. Information superiority and decision making are inextricably linked; in fact, many of the military discussions revolve around exploiting information for the purpose of enhancing decision making (C⁴I Horizon 95: A Vision For the Future, 1995; Johnson, 1994; Link, 1995; Paige, 1996). Based on the discussion of decision making as a primary focus of information superiority, it can be inferred that:

Proposition 3: Decision making is the preeminent *use* activity in attaining information superiority.

As previously discussed, the critical processes in an organization normally fall under the *use* activity (with the notable exception proffered in Proposition 2). The activities usually presented as critical for information superiority, IW, and IO are attacks on enemy information and its functions, and defense of our own functions. These activities are especially touted as essential by the DoD and the Air Force, as shown by the military taxonomy of IW (offensive and defensive). Proposition 2 has already suggested that the *use* activities as a whole are not the most crucial to achieving information superiority.

Proposition 3 further submits that attack and defense, while patently given the most attention in writings and doctrine, are in fact not the most critical of the *use* activities. Support for Proposition 3 provides justification for the selection of decision making as the *use* activity adopted as the context for examination of information superiority in this research.

While not given as much attention as the more glamorous attack activities, decision making is constantly referred to as necessary in information superiority and IW (Brown, 1997; Murphy, et. al., 1996; Paige:1996; Phelan and McGinnis, 1996; Schectman, 1996; Szafranski, 1995). Just as appropriate acquisition is necessary to enable the proper functioning of the subsequent activities in information superiority, so decision making is necessary to most other *use* activities. Decision making may even serve as a form of attack and/or defense. The following cross-section of quotations lends support to proposition 3.

- Speed in decision-making and execution is the best form of information protection (Link, 1995:1).
- Military commanders having information superiority can make wiser decisions, faster than the enemy, about when and where to strike or defend, and with how much force. Defence administrators having information superiority can make wiser decisions about the use of resources, reducing waste, and allowing a greater share of the resource envelope to be directed to improving the combat capability (Brown:1997).
- The essential element common to all professionals is the need to make timely, accurate and supportable decisions to insure competitiveness (Cherney, 1997).
- Armies that seek victory by fighting smarter—and this is now the foundation of U.S. military doctrine—will quickly falter and die if the flow of battle information is interrupted or distorted. Always a factor in separating winners from losers, information now rivals weapons as the commodity most vital to success in war.

- Information is the essence of command and control. Accurate, precise, and timely information lies at the heart of military endeavor on the battlefield.
- The winner is the side that first comes to know the battlefield and is able to cloud or confuse the vision of the opponent (Campen, 1992).
- Information in itself is uninteresting. Information is only useful because someone can do something with it... (Medina-Mora, Winograd, Flores, Flores, 1992:282).
- The faster information is collected, processed, and disseminated to battle commanders, the faster commanders will make decisions leading to military action (Phelan and McGinnis, 1996:225).
- The target of information warfare, then, is the human mind, especially those minds that make the key decisions of war or peace... (Stein, 1995).
- The value inherent in any information-related tactic is its improvement of decision-making relative to the adversary (Schectman, 1996).

Are these widespread opinions substantiated, or is the importance of information a misconception fueled by a few attractive theories with popular appeal? Chapter III's review of decision making theory supports the idea that information is essential to decision making. Browne (1993) suggests that decision making can be characterized as information processing. Walsh (1997) and Teresko (1996) both note that most of the problems stemming from information overload are related to the fact that decision makers are paralyzed by the sheer mass of information available.

From a military viewpoint, Phelan and McGinnis developed a model showing the relationship of information operations, decision making, and military action as part of their research on using Process-Oriented Computer Simulation to investigate information operations. Their "C² Cycle for Military Operations" includes their suggested activities of the information life cycle in information operations (receive, retrieve, process,

transmit, store, discard). The model, presented in Figure 18, shows a circular path from information operations to decision making.

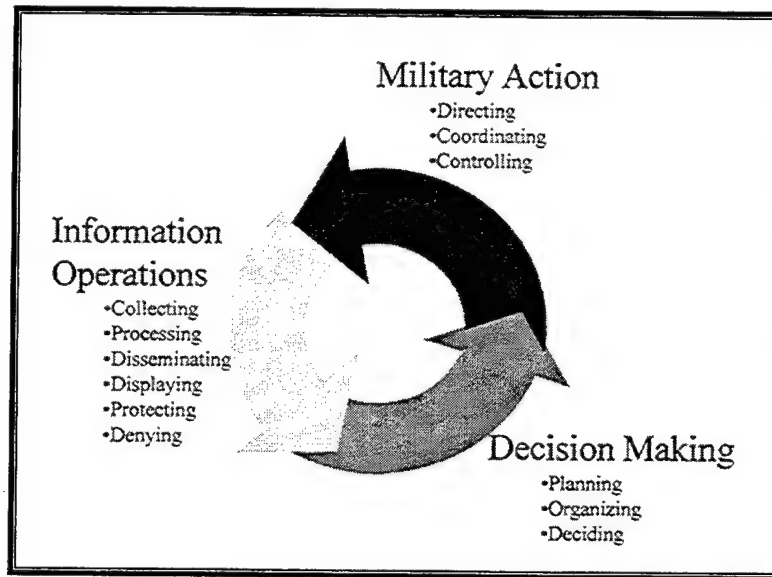


Figure 18. C² Cycle for Military Operations (Phelan and McGinnis, 1996:225)

An experiment examining the effects of information warfare activities on decision making was performed as part of a master's thesis by Donald Dishong. He used a command and control computer simulation called "Tactical Tic-Tac-Toe" to investigate the effects of the "fog of war" (FOW) and delay of information on C² decision makers. The experiment data shows that delaying an opponent from grasping the tactical picture increases the chance of winning battles and completing the mission, and also increases the win-to-loss ratio. It also substantiates the hypothesis that the ability to delay an enemy's comprehension of the strategic picture increases effectiveness through affecting the decisions made by the enemy. Interestingly, while delay of information was shown to have a significant effect, FOW was not. Dishong conjectures that FOW may be too nebulous a concept to measure. He also postulates that FOW is related to uncertainty in

the environment and thus affects both sides equally, canceling out the effects (Dishong, 1994). This experiment may be viewed as support for the fact that attack is an activity of primary importance; nevertheless, it should be noted that the “denial” of information in this experiment was examined *for its effect on decision makers*. In addition, the fact that external uncertainty did not show a significant effect lends credence to a different interpretation for this experiment. The effect was that the decision maker who grasped the picture first won the battle. The experiment suggests that this was because of delay of information to an adversary; however, there exists the possibility that simply possessing the ability to decide faster would yield the same result. A test of this would be a complementary experiment with open information to both parties, a measure of which side was able to make faster use of the information for decision making, and a comparison of the win-loss and mission completion ratio on that basis.

Once information superiority has been defined and its component activities explicated, attention can be turned to determining how these activities can be managed more effectively and efficiently. Information technology is one means by which this can be achieved, and it defines the scope of this research. To this end, it is necessary to examine the role information technology plays in information superiority, particularly in the activities of acquisition and decision making. This relationship can be illustrated through borrowing and transplanting the ideas of Frederick Herzberg’s two-factor theory of motivation (Griffin, 1996). Although information is a vital component of both information superiority and decision making, the usefulness of information technology is not measured on a single continuum, where possessing information technology enables

success while lack of information technology is disabling to the point of failure in all circumstances. Instead, IT should be measured across two dimensions, one ranging from enabling to not enabling, and the other from disabling to not disabling.

In terms of the two-factor theory of information technology, IT is popularly seen as an *enabler* for decision making (Cheney and Dickson, 1982, Huber, 1990; Leidner and Elam, 1995; Molloy and Schwenk, 1995; Saunders and Jones, 1990). While information is an integral part of decision making, information technology is viewed as merely a tool for enhancement. Decisions can be made without using IT, but they cannot be made without some kind of information. In the absence of reliable IT, other means of communicating and assessing alternatives will be used, as shown by the operational assessments of the Army's Task Force XXI digitization exercises.

However, IT can be a *disabler* for other activities in decision making. As in the information superiority process, if too much information is allowed to enter in the acquisition stage, information overload may result, disrupting other activities (Modrick, 1979; Radford, 1978). In particular, too much information can expand the recognition and evaluation phases, simply because the mass of information is too large to handle. As noted by Browne (1993) the "warm glow produced by the possession of a lot of information" does not necessarily lead to effective action. A decision maker's performance is not necessarily improved by amassing great amounts of information. In fact, the contrary is true in some cases, where the individual does not even recognize he or she is suffering from information (Browne, 1993:214). Phelan and McGinnis (1996)

relate that during Desert Storm, communications-computer systems and IT overloaded commanders with information that bogged down the military decision making process.

Winning on high-tech battlefield requires information operations that can win the information war...To fight and win the information war, commanders and staffs at all levels must effectively manage both battlefield information and time for planning and executing the military operation...Information technology will unquestionably accelerate the operational tempo by compressing the C² cycle for military operations...where information operations feed military decision making resulting in military action. (Phelan and McGinnis, 1996:224)

Increased time expended on the separate phases adds to the total time needed to make a decision. In a wartime situation, the increased time may cause the decision making process to expand until it is outside the boundaries of the objectives. Once outside the boundary, the effectiveness of any resulting decision is compromised. As George Patton stated, "a good plan violently executed NOW is better than a perfect plan next week." If acquired information cannot be sifted quickly enough to allow *timely* recognition that a decision situation even exists, the entire decision making process collapses. With this realization, the possibility must be accepted that:

Proposition 4: IT can be a *disabler* for information superiority, unless it is properly used to support the activities inherent in information superiority.

The identification of IT as a disabler for information superiority implies both that IT is a requirement for information superiority and that IT can undermine the ability to attain this goal. Implicit in the definition of information superiority is the requirement for IT. The activities inherent in information superiority and its related elements, IW and IO, are based on acquiring and exploiting information *through the use of information technology*. In today's environment, information superiority cannot be gained or

maintained without IT; as Campen notes, the "information" war requires computer and communication technology (Campen, 1992). The acquisition stage is integral to both decision making and information superiority, and it is the principal activity in information superiority. It has been claimed that IT can cause information overload, thereby disrupting the crucial use process of decision making (Garner, 1991; Landauer, 1995; Modrick, 1979; U.S. Army OTE, 1996/1997; Phelan and McGinnis, 1996; Radford, 1978; Welch, 1979). IT can also degrade the acquisition activity in information superiority, particularly when there is no filtering mechanism for acquisition (Morris, et. al., 1997). Most telling, IT intended to enhance information superiority and other military objectives can be so distracting that it subverts the objectives it is meant to support, to the detriment of the overarching goal of victory. This is illustrated by the Army's experience with "digitizing the battlefield."

The Army conducted the most comprehensive test of battlefield information technology found in the literature. The Task Force XXI Advanced Warfighting Experiment (TF XXI AWE) tested a tactical internet (TI)/appliqué network system intended to perform two main functions: provide situational awareness (SA) to all connected stations and transmit digital C² messages. The experiment equipped units and vehicles with laptops and modem attached to radios, hypothesizing an increase in lethality, survivability, and operations tempo (Holcomb, 1997) Unfortunately,

There was no demonstrated improvement in lethality, survivability, and operational tempo by the digitized force over non-digitized baselines. This is consistent with findings from other digital experiments, including the M1A2 initial operational test. There has been a large increase in fratricide in most of these events, including the latest one. (Holcomb, 1997)

A more stinging assessment charged that information overload detracted significantly from operations. Computer and technical problems diverted commanders' attention from the battlefield and resulted in poor synchronization of weapons use and apparent weakness in combat fundamentals.

The first major test of the Clinton administration's plan to "digitize" the Army by equipping every platoon with a computer degenerated into information overloads, system crashes, and a puzzling increase in friendly fire victims during battlefield exercises...The computer-equipped force suffered self-inflicted casualties more than three times higher than those in previous exercises without computers. (Sloyan, 1997:A13)

Appropriate IT is by definition necessary to information superiority. However, unsuitable IT may be so detrimental it can not only degrade information superiority, but also threaten the overall objectives information superiority is meant to sustain.

Since IT is a requirement of information superiority, but as a disabler can result in adverse consequences if not appropriately applied, the next step is to identify the IT characteristics which are essential to supporting information superiority. An examination of current military IT initiatives and exercise results can be used to identify these vital characteristics.

Task Force XXI Advanced Warfighting Experiment (TF XXI AWE). Despite the mixed results of the Army's digitization experiment, examination of the areas that did work, along with recognition of the problems, can provide insight into characteristics of IT necessary for information superiority. The operational assessments noted several advantages and possible areas for improvement along with the reported problems. These reports collated both quantitative information from data collection devices and qualitative

data based on examinations and comments from subject matter experts (SMEs) in the field. Following is a compilation of analyses of the operational assessments.

The most significant problem was that, on the average, the appliqué was not fully operational at all times. In the first exercise, the system was operational only slightly more than half the time—operational time was calculated as 53 percent from the instrument data and 56 percent based on qualitative SME assessments. There were a range of responses to the question of what percentage of time the system was operational; in some cases, it was operational 80 to 90 percent or more of the time, while in others, it was operational only 10 to 20 percent of the time. Message completion rates were also low, although the rates improved over time. Because of the problem with message completion rates, voice transmissions were increased in order to determine if digital messages had been received, causing contention problems as voice and digital transmissions interfered with each other on the net. In cases where the information had already been received, the decision making process was interrupted due to the reception of redundant information; the digital messaging was mainly an additional task burden, rather than an asset. The human problem was duplicated by system problems in the second exercise; in this case, there were several instances of “hyperactive” terminals, which sent information updates several times as often as they should have, jamming the network. One comment noted that if the platoon leader’s system was down, no one else could communicate the platoon information to higher authorities, causing major interruptions in information flow and disrupting decision making.

On the positive side, when the system was operational, SA was enhanced; it was timely and accurate, SA messages were delivered in 1 second or less, and reported locations were normally within 10 meters or less—as accurate as locations provided by GPS. Most of the SMEs' comments regarding the impact of the TI/appliqué on combat support operations dealt with the capability to enhance SA, as long as the system was operational and utilized. Although the problems with the appliqué hinder it from providing sufficient SA at lower tactical levels, the increased timeliness is of much greater value to the higher echelons, even with the sporadic outages. In addition, the SMEs noted that the system was a good navigational aid; being able to see his position and his unit's position on a map enhanced the commander's ability to orient to his situation and make decisions regarding movement and maneuver of his unit. Also, the system assisted soldiers in preparing and distributing plans and orders, as long as there was sufficient time for planning and preparation—under urgent conditions, message preparation was too cumbersome and took too long.

Some of the qualitative data collected during this exercise is of specific interest to this research. The 26 February 1997 assessment included responses to these three questions, which are of particular significance:

- What effect does digitization have on the commander's ability to disrupt the enemy's decision cycle?

There is no evidence that the information provided though digitization has provided any significant impact to the EXFOR in influencing the enemy decision cycle. It is difficult to post, update, and disseminate enemy information with systems' current state of maturity.

- What impact does digitization have on the collection and analysis of information to produce and disseminate battlefield intelligence?

There is no evidence supporting that dissemination of battlefield information over digital media has had any positive impact on the EXFOR. As in other areas, the potential for positive impact exists, but is precluded by the overall immaturity of digital systems.

- How does digitization affect timeliness of information dissemination?

Digitization has had only minimal impact on information transmission in the EXFOR. Usually information requiring immediate action or relating to current operations during mission execution is passed by FM [frequency modulation] voice...the current C² messaging capability is too cumbersome and slow to impact information dissemination positively. (U.S. Army OTE, 26 February 1997:3-9 to 3-10)

The last assessment concludes that the TI/appliqué worked well enough to demonstrate the potential of a digitized battle system. There were two cautionary reminders: although training proficiency increased with each exercise, it is unlikely that operators achieved full proficiency; and the system is still in the concept development phase, meaning that operators were working with continuously changing prototype hardware and software. The increased SA which can potentially be provided has enormous potential for the future battlefield; in fact, friendly SA information was the highlight of the AWE. This information provided significant assistance in executing vehicle movement and maneuver, helping tactical operations centers track the battle better and allowing commanders to focus more energy on other tactical tasks. However, the fratricide incidents show this increased SA is not sufficient to prevent fratricide by itself. Although not always timely and useful, enemy SA provided favorable information and showed potential for future use. Overall, the assessment concludes that a future

digital system shows great promise for combat utility, but the current system requires considerably more development to meet this potential.

Global Correlation Engine. The Global Correlation Engine (GCE) fuses data from all types of sources and sensors in order to produce and maintain a tactical database. Its purpose is to expand the range and effectiveness of sensors and weapons, and to improve a commander's situation awareness. The current development model runs on multiple UNIX-based computers across a network. Capabilities in development include allowing the GCE to use parallel processors and allocate resources as necessary.

The GCE is mainly a tactical decision aid, using non-Gaussian tracking methods to represent more real-life situations in tactical and intelligence environments. In real-world situations, there are many different types of targets. Many of these are easily detectable and of little interest. For the larger number of targets which are more easily detected through linear modeling, the GCE uses a "multiple hypothesis correlator" to track targets through probability methods. However, a smaller proportion of targets are difficult to detect using linear methods, yet they are extremely important to the battle. Trained personnel can use a non-Gaussian computer assisted search system to plan and coordinate surveillance and tracking of these targets. The nonlinear techniques can provide better time location estimates and more accurately project the tactical situation into the future, in addition to allowing optimal allocation of weapons and sensor resources. This allocation requires the use of intrinsically non-Gaussian data such as negative information (failure to observe a target) and location and motion data. The GCE is intended to be a fully integrated multiple hypothesis correlation and non-Gaussian

tracking and search planning system. It has direct access to tactical databases, and can use its combined capabilities to not only identify a target and model its probable level of threat or interest, but also update the tactical database, correlating and fusing tactical information into reports of interest to decision makers. The GCE uses computer information processing capabilities to enhance the abilities of decision makers in a tactical targeting scenario and to assist in improving a commander's situational awareness of the battlefield environment. In this case, information technology appears to provide enhancement to decision maker's abilities. It is interesting to note that the GCE is meant to perform a certain task—the information acquired by this system is specified, rather than gathered in indiscriminate masses.

RAND Metadata Management System. Many organizations possess numerous databases containing information necessary for operation, but documentation and descriptive information is often not included. In order for these databases to be effectively used and shared, additional information defining and describing the databases and their contents is needed. Such descriptive and definitional information about databases, simulation models, and procedures is called *metadata*. Interoperable systems must agree on the meaning and usage of data elements and domain concepts, thus metadata is necessary to facilitate data sharing and interoperability across functional areas of an application (Cammarata, 1995). A metadata management system such as RMMS is useful both for developers of future systems, who can use the metadata for different systems to derive a new overarching system, and for users of current dissimilar systems, who can use a metadata repository as a reference for all associated databases which

contain information about the item of interest. RMMS itself has been used to manage metadata for military databases which serve as input to simulation models (Cammarata, 1995:20). Metadata is necessary to bridge the gap between systems or applications which need to share their data with each other, and as these proliferate, the need for systems to manage the metadata becomes more prevalent.

C⁴I For The Warrior. The C⁴I For The Warrior (C⁴IFTW) concept is the DoD vision of interoperable systems and a common information infrastructure across the full spectrum of military operations. It is the epitome of information superiority.

The C⁴I for the Warrior (C⁴IFTW) concept is committed to the challenge of meeting the warrior's quest for information needed to achieve victory for any mission, at any time and at any place. C⁴IFTW is the vision and roadmap for creating a broadly connected joint system that provides total battlespace information to the warrior. (DISA, 1997)

There are four major facets of the C⁴IFTW concept: command and control, transmission, messaging, and combat support. Several initiatives have grown out of the C⁴IFTW vision, including systems correlating to each of the four principal aspects. The overall concept is illustrated in Figure 19.

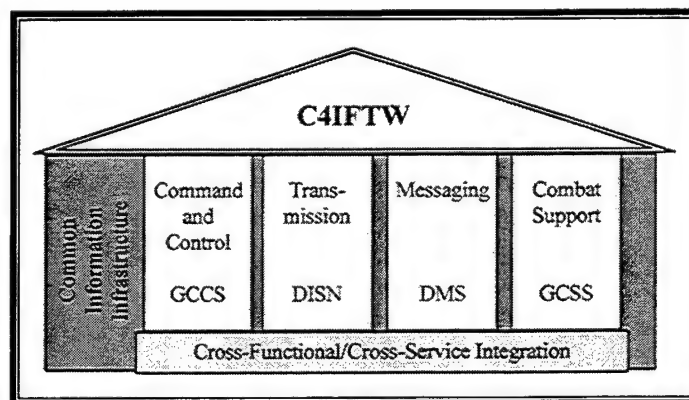


Figure 19. C⁴IFTW and Supporting Initiatives

Global Command and Control System. The Global Command and Control System (GCCS) is an initiative to provide command and control through supplying information processing and sharing capabilities to warfighters and decision makers. When fully implemented, it should assist decision makers at all levels (strategic, operational, and tactical), as its goal is to ensure access to battlespace information allowing missions to be planned, executed, and managed. The previously used system, the World Wide Military Command and Control System (WWMCCS), focused on communications. It could pass messages and instructions, but was not designed to process or transmit large amounts of data. Systems which could process quantities of information (such as maps, targeting information, etc.) were unable to communicate this information to other systems. Furthermore, the transmitted data was not accessible across the services. In response to this problem, the DoD established the GCCS initiative, to be composed of interconnected joint systems providing seamless access to all battle space information.

[GCCS is a] globally connected, warrior-involved, interoperable, fully-integrated C⁴ system. The GCCS core consists of the basic functions required by the warfighter to plan, execute, and manage military operations. These functions are then satisfied by selecting the applications from existing C² systems that best meet the requirement. This ensures interoperability, minimizes training requirements and allows efficient use of limited defense resources. (Global Command and Control System, 1997)

It has been used in conjunction with the Air Expeditionary Force (AEF) as a tool to enhance command and control. GCCS provides the AEF wing operations center with a common operating picture which identifies friendly, coalition, and enemy force positions, in addition to information on logistics, deployment schedules, and intelligence. The system furnishes direct linkage between the AEF commander, the Joint Force

commander, the regional commander, and the National Command Authority (Gruber, 1997).

GCCS is being implemented across all the services to ensure a joint common operating environment within the Defense Information Infrastructure (DII). By allowing commanders to receive and transmit battlespace information in addition to C² messages to the soldiers in the field, decision making is enhanced at the operational and tactical level. The availability of the system is a factor in strategic planning and decision making providing an infrastructure to effectively control the flow and processing of information in implementing command and control. Both the time needed to make a decision and quality of the decision made can be affected with an interoperable system capable of transmitting full information.

Defense Information System Network. The Defense Information System Network (DISN) addresses the need for an integrated transmission infrastructure which can take advantage of evolving technology, dynamic bandwidth, and the changing needs of decision makers. The mission needs statement for DISN declares that the transmission system supporting C⁴IFTW must

...be global and seamless in connectivity, scaleable in capacity, flexible in provisioning, easily extended to any location in the world, and capable of accepting technology insertions and value-added services in support of future warfighting requirements. When contingencies and conflicts arise, warfighters will need continuous C⁴I connectivity as they transition from the sustaining base to their respective areas of operation. The network providing C⁴I support must be flexible enough to handle rapid expansion of connectivity/bandwidth (dynamic reallocation) requirements to support all JTF/CTF operations. (Joint Staff, 1995)

DISN is the system proposed to meet these requirements. When fully implemented, DISN is expected to provide dominant battlespace awareness and information dominance to commanders and decision makers. Its transmission capabilities support not only the overall C⁴IFTW concept, but the other initiatives which depend on rapid and accurate information transfer.

Defense Messaging System. As evident from its name, the Defense Messaging System (DMS) is the facet of C⁴IFTW concerned primarily with providing message service. It consists of the hardware, software, personnel, procedures, and facilities needed for electronic message delivery to personnel and organizations, including deployed tactical users and joint and allied members. DMS is meant to provide global, interconnected electronic messaging capability direct to the end user.

Although DMS may seem less glamorous than the other components of C⁴IFTW, it is nonetheless important to the decision maker. Quick, reliable transmission of messages directly impacts the time needed for the action phase of decision making. The seeming simplicity of this task is deceptive; recall the recurring problems which were never quite resolved in the TF XXI AWE. DMS is also likely to be the most well-known facet and most-used facet of C⁴IFTW, as it is being built on a foundation including the current Automatic Digital Network (AUTODIN) system familiar to most military members, and the electronic mail systems currently on the DoD internet.

Global Combat Support System. The Global Combat Support System (GCSS), the final piece of the C⁴IFTW concept, uses the same approach, methodology, practices, tools, and integration procedures as GCCS, but is directed toward combat support

functions rather than command and control. The DISA GCSS webpage furnishes a concise view of GCSS and the problems it is meant to overcome.

The problem facing The Joint Task Force today is they have several unique mission application stovepipes such as acquisition, logistics, engineering, finance and health services. These applications are not integrated, and may contain inaccurate or conflicting data. GCSS will eliminate these stovepipe systems and develop shared databases of information. GCSS is a demand-driven, joint warfighter-focused initiative to accelerate delivery of improved combat support capabilities. It is a strategy that integrates existing combat support systems to gain efficiency and interoperability in support of the warfighter. GCSS will provide the warfighter with a fused, real-time combat support view of the battlespace. (Global Command and Control System, 1997)

GCSS also expands the availability of information to provide the joint task force commanders with more tactical options. The commanders' access to all the data and all the applications necessary to do the job comes from a single computer. This capability involves a process rather than hardware and software systems as they generally are known. (Robinson, 1996)

GCSS is the combat support side of command and control. It will provide decision makers with an integrated picture of activities supporting combat, allowing them to orient to the overall environment and make better-informed decisions.

Joint Warrior Interoperability Demonstration 1997 (JWID 97). JWID 97 was a collection of technology demonstrations to test and support several of the initiatives associated with the C⁴IFTW concept. Some of the goals and objectives of JWID 97 are directly applicable to the ideas examined in this research. For example, the goals of JWID 97 included:

- Demonstrate real-time and seamless information exchange between multiple levels of security at the CTF and component level, particularly for the purposes of command and control and collaborative planning.
- Demonstrate innovative telecommunications and information management technology that enhances data delivery to and from Joint Warriors at the unit level, particularly common operating picture and imagery.

- Demonstrate sensor-to-sensor and sensor-to-shooter technologies to enhance combat identification and theater missile defense in a coalition environment and to provide targeting information.
- Demonstrate technologies that enhance information superiority through the use of Information Operations/Information warfare. These technologies should provide assurance of coalition access, use, and integrity of command, control, communications, computer, intelligence, surveillance, and reconnaissance (C⁴ISR) systems while preventing unauthorized use of the same. (JWID 97, 1997:n. pag.)

JWID 97 demonstrations included testing of the four principal aspects of C⁴IFTW, with varying degrees of success. Evaluation and assessment of the demonstration is still ongoing at this time, but initial impressions were reported in the final situation report posted on the C⁴I-Pro electronic mail forum. Overall, the demonstration was considered a success. Integration of a common operating picture and development of a central database were among the most notable successes. One of the brightest successes in JWID 97 was associated with what may have been the most ambitious project, development of the Coalition Wide Area Network (CWAN). The purpose of the CWAN was to link the United States with its allies worldwide, providing real-time collaborative planning with coalition partners. With all coalition partners on a network having access to the same information, reaction time was expected to decrease and warfighting capabilities increase under changing battlefield conditions. The CWAN

...was considered by most as the number one item to emerge from JWID 97. The CWAN facilitated overall collaborative planning, improved situational awareness, and was up and operational from start to finish. It is a necessity for Joint and Coalition warfare in the future. (McSorley, 1997)

From this examination of technologies and experiments, it is possible to extract the characteristics which are perceived to be important to information technology having

a positive impact. Due to the frequency with which these issues are addressed or set as objectives in the studied cases, we can conclude that these are the major issues which must be considered when designing and implementing any information technology in support of information superiority. The characteristics most prevalent and thus presumably thought to be most important are:

- Interoperability of systems
- Communication capabilities
- Information sharing capabilities
- Information gathering ability
- Information processing

Interoperability is a basic aspect allowing the other characteristics to be attained. The other attributes show a distinct correlation to the activities intrinsic to the information superiority process model. Based on this analysis of current initiatives:

Proposition 5: Information superiority requires information technology which can provide communication, information sharing, information gathering, and information processing capabilities.

The following matrix shows the distribution of these characteristics among the examined initiatives/experiments.

Table 7. Matrix of IT Aspects and Initiatives

	Communication	Information Sharing	Information Gathering	Information Processing
TF XXI AWE	X	X	X	X
GCE		X	X	X
RMMS		X	X	
<i>C⁴IFTW</i>	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>
• GCCS		X	X	X
• DISN	X			
• DMS	X			
• GCSS		X	X	X
JWID 97	X	X	X	X

It is interesting to note that the most prevalent requirements are information gathering and sharing. Information sharing is usually presented as a requirement to support the information needs of the users; it is allied with communication, but its primary use is as an input to information gathering. It was an aid to SA in the AWE and JWID 97, and it can provide a common information picture when used in GCCS and GCSS. The fact that information gathering and information sharing as an aid to providing information are most prevalent in IT initiatives tends to support the premise of Proposition 2, that acquisition is the chief activity in information superiority.

Summary

This chapter developed a series of propositions directed at the heart of this research—how to achieve information superiority. Using the definition of information superiority provided in the previous chapter, a process model was created to assist in developing the propositions. The primary activities of information superiority,

acquisition and use in the context of decision making, were discussed. Finally, initiatives intended to leverage information superiority by using IT were examined, and essential characteristics required to allow IT to contribute to information superiority were identified.

V. Conclusions and Recommendations

This research explored the concept of information superiority and the idea that information technology is necessary to achieving this objective, with research organized around the central research question:

What activities are essential for the attainment of information superiority, and how can we apply information technology in support of these activities?

A conceptual map was developed as a framework to assist in gathering information about this idea, and an investigation of each concept was conducted for the purposes of defining the ideas, in addition to an examination of information technology initiatives. Expanded process models of information superiority and decision making were also developed.

These exercises aided the formulation of a series of propositions about information superiority and the influence of information technology on achieving this goal through management of its core activities.

The initial concept map (shown again in Figure 20) included the idea of information superiority, the concepts bounding the area of study, and the hypothesized relationships between them.

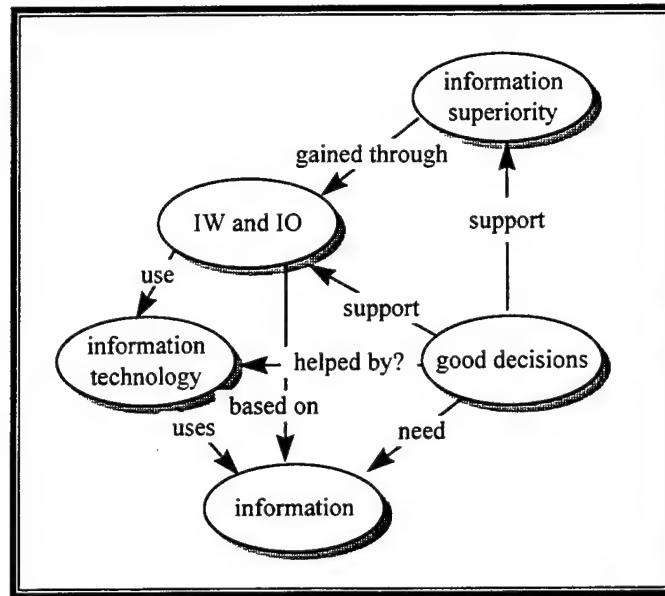


Figure 20. Initial Concept Map Delineating Research Area

To facilitate data collection, the concept map was refined into a conceptual model (represented in Figure 21), with the illustrated relationships delineating the area of study.

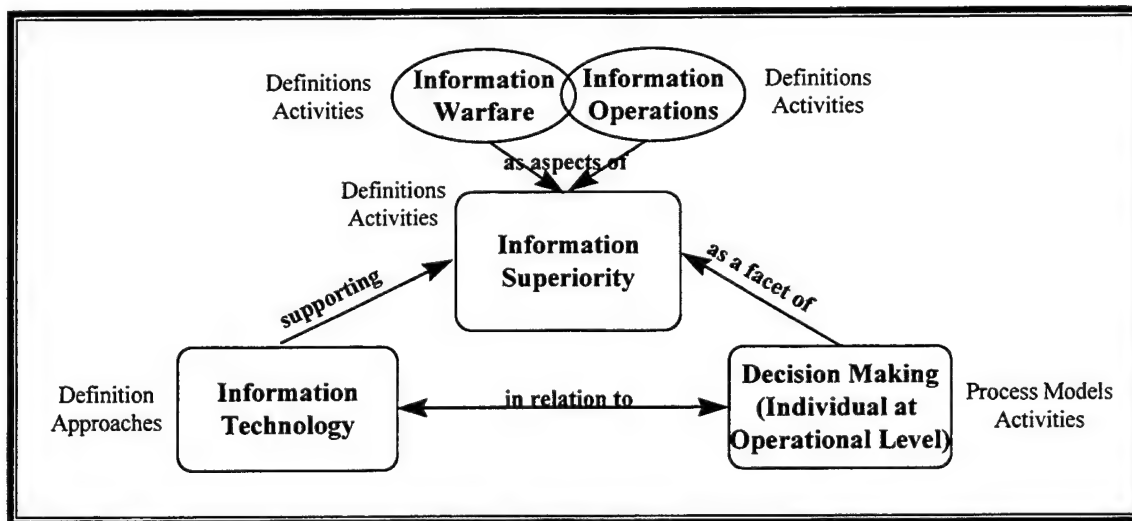


Figure 21. Conceptual Model of this Research

Analysis of the data collected during this research was used to develop several propositions, which are discussed in Chapter IV. The analysis process, in conjunction

with the subsequent propositions, suggested necessary refinements to the conceptual model. Information warfare and information operations were described as facets of information superiority, with the component activities of *acquisition*, *storage*, *use*, and *transmission* of information. As with any resource, information must be used in some manner to create value, but before it can be used, the information must be acquired from somewhere and processed into a usable form. The information resource may be "created" from assembling data contained in someone's head or in an information system, gathered from the internal or external environment, or received through transmission from another source. If the information is not immediately needed, it may be stored until required or disseminated to those who have an immediate need. Examination of the information concepts revealed that the use of information involves many of the activities of IW and IO. Activities such as exploitation of information, denial or corruption of enemy information, targeting, and employment of information in planning or decision making are all *use* activities, manipulating information to produce an output of value.

From an analysis of the literature and the preeminent definitions of information superiority, decision making was determined to be the principal *use* activity. Definitions of information superiority show one of the main focal points of each information concept is the decision maker, and other models and research bear out this conclusion (Dishong, 1994; Phelan and McGinnis, 1996; Schectman, 1996). However, the *acquisition* activity, common to both information superiority and decision making, was judged to be the most critical, requiring careful management and filtering to ensure only relevant information enters the process. The problems which arise when this filtering does not take place are

apparent from a systems analysis report done for AFMC/ST, in which it was discovered that information necessary to budget decisions related to the Modernization Planning Process was not readily available. Necessary information was stored in several different areas, and responses to queries yielded inconsistent, late, and often erroneous information (Morris, et. al, 1997). Another disastrous example resulting from the lack of a filtering mechanism for masses of information was the Khobar Towers bombing in Dhahran, Saudi Arabia. One of the officers in charge stated that there were so many intelligence reports he was unable to sift them for the critical information that could have alerted officials to the target (Walsh, 1997). A suggestions for organizing and filtering information includes the application of information engineering principles, especially information strategic planning to determine critical processes and the information needed to support those processes. Related to information engineering is the proper use of available information technologies such as data warehousing, which allows an organization to collect data from operational environments and store it in a suitable format for the desired use (Teresko, 1996).

Finally, an analysis of military information technology initiatives and related experiments revealed that IT can be a *disabler* for information superiority. As shown by the problems in the Army's Advanced Warfighting Experiment, IT can actually be detrimental unless it supports the essential characteristics of information gathering, information sharing, communication, and information processing. In this exercise, the use of IT distracted commanders and slowed down their decision making in the field. The complexity of the technology also inhibited soldiers from performing their duties,

and it was believed to have affected the fratricide rate in the exercise (Slovan, 1997). Examination of several military IT initiatives and exercises, including the AWE, C⁴IFTW, and JWID 97 resulted in the identification of four essential IT characteristics related to and supporting the information superiority activities. These IT characteristics are: information gathering, information sharing, communication, and information processing. Ensuring the integration of these characteristics and the information activities can contribute to the achievement of information superiority, as illustrated by the success of the CWAN in JWID 97 and the lauded increase in SA in the AWE.

In terms of the conceptual model, the outcome of this research can be illustrated by the refined model shown in Figure 22.

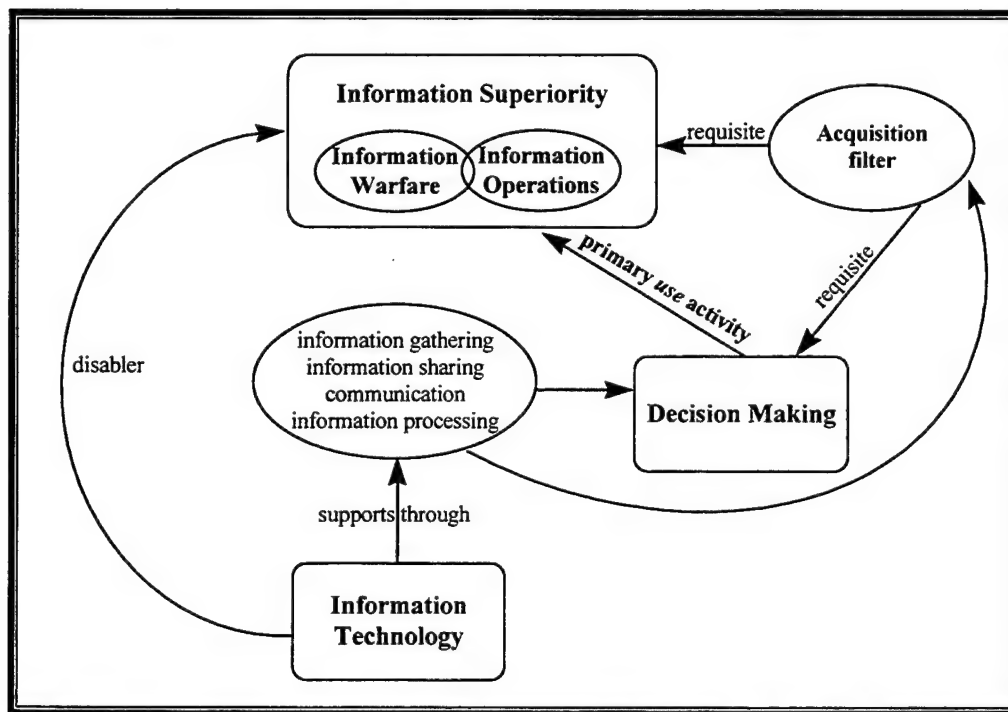


Figure 22. Information Superiority Conceptual Model Resulting from this Research

Answers to Research Questions

The first research question, defining information superiority and its related concepts of IW and IO, was addressed in Chapter III. Chapter IV developed propositions in answer to the remaining research questions. The first three propositions address ways to enhance information superiority, providing answers to the second research question:

What are the principal activities required for information superiority, and how can we manage these activities to achieve this goal?

Proposition 1 identifies the specific activities involved in information superiority, while Propositions 2 and 3 suggest which of these activities are most important. Propositions 4 and 5 discuss the role of IT in information superiority from opposing viewpoints as a means of answering research question 3, to wit:

What role does information technology play in promoting information superiority?

Proposition 4 notes that IT can be a detriment to information superiority, while Proposition 5 reflects the characteristics needed in order to allow IT to support information superiority. The discussion surrounding Proposition 5 is based on a number of case study vignettes drawn from current military IT initiatives and experiments. This proposition can be used both to bolster Proposition 2 and to draw conclusions about whether the military is heading in the appropriate direction in its quest for information superiority.

Recommendations

Recommendations can be made based on the findings of this study and the developed propositions. This section briefly presents recommendations associated with each proposition. Proposition 1 suggests that information superiority can be achieved by managing the appropriate information activities (acquisition, storage, transmission, and use). In light of this proposition:

Recommendation 1. Information superiority doctrine should stress the management of the activities necessary for information superiority rather than the development of information technology for its own sake.

Propositions 2 and 3 indicate that the key activities in information superiority are acquisition and decision making. Proper management of the acquisition activity is important both to information superiority overall and to the integral decision making *use* activity.

Recommendation 2. The military should shift focus to the acquisition and decision making activities of information superiority, rather than excluding them or following the tendency to pursue the more combat-oriented activities of attack, targeting, and defense.

The need to better manage the acquisition and use of information entails the application of information engineering and IRM techniques to filter information and ensure the entry of only germane information into the process. Along with identifying the activities which should be concentrated on in the military's attempt to ensure information superiority, this research substantiates the idea that information technology

can contribute to information superiority, *but only if it possesses the proper characteristics*. A review of initiatives and experiments provides insight into what those aspects are. It should be recognized that IT as a generic concept is not an enhancement to information superiority; in fact, it can be a detriment. IT must be appropriate to information superiority and its activities, or neither information superiority nor the overall goal of victory can be achieved. When the right information is collected, other activities can be enhanced, as shown by the increase in SA in the AWE and the targeting potential of the GCE. The success of the JWID 97 CWAN illustrates the value of disseminating information quickly and accurately. As the matrix in Table 7 shows, IT should include communication, information sharing, information gathering, and information processing capabilities. The C⁴IFTW concept, with its vision of integrated facets of command and control (GCCS), transmission (DISN), messaging (DMS), and combat support (GCSS), covers the essential IT aspects. These aspects used in conjunction with information engineering and IRM ideas should greatly enhance our ability to achieve information superiority.

Recommendation 3. The military should continue development and testing of IT with the characteristics of information gathering, information sharing, communication, and information processing, while recognizing the applicability and association of these characteristics to the core activities of information superiority. IT should be used in conjunction with information strategic planning and management of information resource activities to ensure the right information is gathered, processed, and transmitted.

Limitations of the Research

This research used exclusively qualitative methods, as explained in Chapter II. The model developed in this research has not been tested or examined for applicability to empirical research methods. This thesis was limited to developing a model of information superiority and propositions to support it; no quantitative data was collected or examined. While the cases studied were representative of maximum variation sampling, the case studies were accumulated as a convenience sample using the snowball approach. As in the literature search, the sheer mass of available information prevented an exhaustive review, creating the possibility that some relevant cases were not included. In particular, there may be some very new initiatives which have very little written information or are relatively unknown at this time, but may be pertinent to future research of this type. This research also focused solely on military initiatives and exercises; the results may not be generalizable to non-military organizations which operate in a different environment.

Suggestions for Further Research

Complementary research should be done to examine means other than information technology which can be used to support the acquisition and decision making activities important to information superiority. In addition, a more detailed examination of the chief IT characteristics is possible to determine their levels of applicability to each activity in information superiority. As information superiority doctrine develops further, there will be a need for additional research to either determine if there is a shift in the

primary information activities or revalidate the conclusions reached in this study. The information superiority process model and the resulting propositions can be used as a basis for further study, or to corroborate or refute the conclusions reached in this research.

Conclusion

In its pursuit of information superiority, the DoD is on the right track as far as the characteristics it feels are important in information technology. However, the doctrine development surrounding information superiority and its supporting activities of information warfare and information operations is concentrating on the wrong areas. To align the quest for information superiority with the development of information technology initiatives in support of this goal, the military should refocus on the activities of acquisition and use of information, especially use for decision making. Acquiring the appropriate information, and using it for effective decision making, along with the support of suitable information technology, yields the key to information superiority.

Appendix A: Glossary of Acronyms

ACC	Air Combat Command
AEF	Air Expeditionary Force
AF	Air Force
AFB	Air Force Base
AFDD	Air Force Doctrine Document
AFIT	Air Force Institute of Technology
AFM	Air Force Manual
AFMC	Air Force Materiel Command
AFMC/ST	Air Force Materiel Command Science and Technology Directorate
AUTODIN	Automatic Digital Network
AWE	Advanced Warfighting Experiment
BM/ C ²	Battle Management/Command and Control
C ²	Command and Control
C ³	Command, Control, and Communications
C ⁴	Command, Control, Communications, and Computer
C ⁴ I	Command, Control, Communications, Computer, and Information
C ⁴ IFTW	Command, Control, Communications, Computer, and Information for the Warrior

C ⁴ ISR	Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance
CCIR	Commander's Critical Information Requirements
CIA	Central Intelligence Agency
CJCS	Chairman of the Joint Chiefs of Staff
COMPUSEC	Computer Security
COMSEC	Communications Security
CPEA	Concept, Planning/Preparation, Execution, and Assessment
CSCW	Conference on Computer-Supported Cooperative Work
CTF	Coalition Task Force
CWAN	Coalition Wide Area Network
DA	Department of the Army
DAF	Department of the Air Force
DII	Defense Information Infrastructure
DISA	Defense Information Systems Agency
DISN	Defense Information Systems Network
DMS	Defense Messaging System
DoD	Department of Defense
EXFOR	Exercise Force

FM..... Field Manual

FOW..... Fog of War

GCCS..... Global Command Control System

GCE..... Global Correlation Engine

GCSS..... Global Combat Support System

GPS..... Global Positioning Sensor

HQ..... Headquarters

IEW..... Intelligence and Electronic Warfare

IO..... Information Operations

IRM..... Information Resource Management

IS..... Information Systems

IT..... Information Technology

ITMRA..... Information Technology Management
Reform Act

IW..... Information Warfare

JTA..... Joint Technical Architecture

JTF..... Joint Task Force

JV 2010..... Joint Vision 2010

JWID..... Joint Warrior Interoperability
Demonstration

MNS..... Mission Needs Statement

MPP..... Modernization Planning Process

Bibliography

- Ackerman, Robert K. "Commercial Information Systems Proliferate in Military Operations." Online article, n. pag. *SIGNAL Magazine*, January 1997. WWWeb, <http://www.us.net/signal/Archive/Jan97/commercial-jan.html>. 2 September 1997.
- Ackoff, Russell L. "Management Misinformation Systems," *Management Science* 34(4): B147-B156 (December 1967).
- Archer, N. P., M. M. Head, and Y. Yuan. "Patterns in information search for decision making: the effects of information abstraction," *International Journal of Human-Computer Studies*, 43: 599-616 (1996).
- Arnold, Wallace C. and Thomas H. Killion. "MANPRINT: Battle Command and Digitization," *Military Review*, 48-55 (May-June 1995).
- Ashby, Dianne E., D. Michele Maki, and Ann Cunningham-Morris. "Organizational Development: Using Data for Decision Making," *Journal of Staff Development*, 17(1): 8-11 (Winter 1996).
- Attewell, Paul and James Rule. "Computing and Organizations: What We Know and What We Don't Know," *Communications of the ACM*, 27(12), 1184-1191 (December 1984).
- Benbasat, Izak. "An Analysis of Research Methodologies," in *The Information Systems Research Challenge Proceedings*, Ed. F. Warren McFarlan. Boston MA: Harvard Business School Press, 1984.
- Berkowitz, Bruce D. "Warfare in the Information Age," *Issues in Science and Technology*, 12(1): 59-66 (Fall 1995).
- Binaghi, Elisabetta and Anna Rampini. "Fuzzy decision making in the classification of multisource remote sensing data," *Optical Engineering*, 32(6): 1193-1204 (June 1993).
- Boyd, John R. "A Discourse on Winning and Losing." 1987. Unpublished set of briefing slides available at Air University Library, Maxwell AFB AL, Report no: mu43947.
- Braunberg, Andrew C. "Air Force Pursues Two-Sided Information Warfare Strategy," *Signal*: 63-65 (July 1996)

- Brown, A. R. (Tony). "National Défense—Information Technology Directions for the Department of National Defence and Canadian Forces." Online article, n. pag. WWWeb, http://www.dnd.ca/admdis/library/power/power_e.htm. 12 February 1997.
- Browne, Mairead. *Organizational Decision Making and Information*. Norwood NJ: Ablex Publishing Corporation, 1993.
- Buchanan, John T. "An Experimental Evaluation of Interactive MCDM Methods and the Decision Making Process," *OR: The Journal of the Operational Research Society*, 45(9): 1050-1059 (September 1994).
- "C⁴I Horizon 95: A Vision of the Future." Military Document, n. pag. WWWeb, <http://infosphere.safb.af.mil/~rmip/h95toc.htm>. 12 February 1997.
- Calhoun, Kenneth James. *The Application of Information Technology in Decision-Making*. Ph.D. dissertation. University of Pittsburgh, Pittsburgh PA, 1991 (AAK-6217)
- Cammarano, Roy. "3-D Decision Making: A Model for Making the Best Choices," *Success*: 82 (June 1994).
- Cammarata, Stephanie, et. al. *The RAND Metadata Management System (RMMS): A Metadata Storage Facility to Support Data Interoperability, Reuse, and Sharing*. Santa Monica CA: RAND, 1995.
- Campen, Alan D., ed. *The First Information War: The story of communications, computers, and intelligence systems in the Persian Gulf War*. Fairfax VA: AFCEA International Press, 1992
- Cannon-Bowers, Janis A., Eduardo Salas, and John S. Pruitt. "Establishing the Boundaries of a Paradigm for Decision-Making Research," *Human Factors* 38(2): 193-205 (June 1996).
- Carroll, John S. and Eric J. Johnson. *Decision Research: A Field Guide*. Newbury Park CA: Sage Publications, 1990
- Cason, Timothy N. "The Impact of Information Sharing Opportunities on Market Outcomes: An Experimental Study," *Southern Economic Journal*, 61(1): 18-39 (July 1994).

- Chairman of the Joint Chiefs of Staff (CJCS). *Joint Vision 2010*. Pentagon, Washington DC, 1996.
- Cheney, P. H. and G. W. Dickson. "Organizational Characteristics and Information Systems: An Exploratory Investigation," *Academy of Management Journal*, 25(1): 170-184 (1982).
- Cherney, David. "Business Information Dominance." Online article, n. pag. WWWeb, <http://www.cherney-assoc.com/index.htm>. 16 March 1997.
- "CIA Director John Deutch's Statements on Cyberwar." Excerpt from speech, n. pag. WWWeb, <http://www.parascope.com/ds/cyber3.htm>. 16 May 1997.
- Clausewitz, Carl von. *On War*, translated by Michael Howard and Peter Paret. Princeton NJ: Princeton University Press, 1989.
- Coe, Gary Q. and John T. Dockery. "OJCS Initiatives in C² Analysis and Simulation," in *Science of Command and Control: Coping With Uncertainty*. Stuart E. Johnson and Alexander H. Levis. Washington DC: AFCEA International Press, 1988.
- Cooper, Jeffrey. "Dominant Battlespace Awareness and Future Warfare," in *Dominant Battlespace Knowledge: The Winning Edge*. Ed. Stewart E. Johnson and Martin C. Libicki. Washington DC: National Defense University Press, 1995.
- "Defense Information Infrastructure (DII) Shared Data Environment (SHADE) Capstone Document, Version 1.0, 11 July 1996." Military document. WWWeb, <http://spider.osfl.disa.mil/dii/shade/shdcap.html>. 9 Oct 1997.
- Defense Information Systems Agency (DISA). "Global Combat Support System (GCSS)." Excerpt from military online information, n. pag. WWWeb, <http://www.disa.mil/line/gcss.html>. 6 August 1997.
- Dennis, Alan R. "Information Exchange and Use in Group Decision Making: You Can Lead a Group to Information, But You Can't Make It Think," *Management Information Systems Quarterly*, 20(4): 433-455 (December 1996).
- Denzin, Norman K. and Yvonna S. Lincoln, Ed. *Handbook of Qualitative Research*. Thousand Oaks: SAGE Publications, 1994.
- Department of the Air Force (DAF). *Basic Aerospace Doctrine of the United States Air Force, Volume II*. AFM 1-1. Essay C: Human Factors in War; 17-23. Washington: HQ USAF, 1 March 1992a.

- . *Basic Aerospace Doctrine of the United States Air Force, Volume II*. AFM 1-1. Essay F: Three Levels of War; 43- 49. Washington: HQ USAF, 1 March 1992b.
- . *Cornerstones of Information Warfare*. USAF Concept Paper. Washington DC: HQ USAF, 11 August 1995a.
- . *Global Engagement: A Vision for the 21st Century Air Force*. Washington DC: HQ USAF, 1996.
- . *Information Warfare: Pouring the Foundation*. Air Force Doctrine Document (AFDD) 5. Washington DC: AF/XOXC, 1995b.
- Department of the Army (DA). *Information Operations*. FM 100-6. Washington DC, 27 August 1996.
- . "Draft Brochure—Information Operations, 22 January 1997." U.S. Army draft document, n. pag. WWWeb, <http://www.fas.org/irp/doddir/army/iobro382.htm>. 12 September 1997.
- Dishong, Donald J. *On Studying the Effect of Information Warfare on C² Decision Making*, M.S. Thesis, Naval Postgraduate School, 1994 (AD-A283 639).
- Dockery, John T. "The Use of Fuzzy Sets in the Analysis of Military Command," in *Decision Information*. Ed. Chris P. Tsokos and Robert M. Thrall. New York: Academic Press, 1990.
- "DoD Dictionary of Military Terms—Information Superiority." Online military information, n. pag. WWWeb, <http://www.dtic.mil/doctrine/jel/doddict/data/i/02928.html>. 16 May 1997.
- "DoD Dictionary of Military Terms—Information Warfare." Online military information, n. pag. WWWeb, <http://www.dtic.mil/doctrine/jel/doddict/data/i/02930.html>. 16 May 1997.
- "DoD Joint Technical Architecture (JTA)." Military document, n. pag. WWWeb, <http://www-jta.itsi.disa.mil/>. 6 August 1997.
- Eden, Colin and John Harris. *Management Decision and Decision Analysis*. New York: John Wiley & Sons, Inc., 1975.
- Eisenhardt, Kathleen M. "Speed and Strategic Choice: How Managers Accelerate Decision Making," *California Management Review* 32(3): 39-53 (Spring 1990).

- Finnegan, Pat and Lynda O'Mahoney. "Group problem solving and decision making: an investigation of the process and the supporting technology," *Journal of Information Technology*, 11(3): 211-221 (1996).
- Fogleman, Ronald R., Air Force Chief of Staff. "Information Operations: The Fifth Dimension of Warfare." Remarks delivered to the Armed Forces Communications-Electronics Association, Washington, April 25, 1995, in *Defense Issues* 10(47). WWWeb, <http://www.defenselink.mil/pubs/di95/di1047.html>. 12 May 1997.
- Foster, Lawrence W. and David M. Flynn. "Management Information Technology: Its Effects on Organizational Form and Function," *Management Information Systems Quarterly*, 8: 229-236 (December 1984).
- Frederikson, E.B. "Noneconomic Criteria and the Decision Process," *Decision Sciences*, 2 Jan 1971, 23-52.
- Garigue, Robert John. "Information Warfare: Developing a Conceptual Framework—Draft Version 2.1." Unpublished concept document. WWWeb, <http://www.carleton.ca/~rgarigue>. 12 May 1997.
- Glazer, Rashi, Joel H. Steckel, and Russell S. Winer. "Locally Rational Decision Making: The Distracting Effect of Information on Managerial Performance," *Management Science*, 38(2): 212-226 (February 1992).
- "Global Command and Control System." Excerpt from military online information, n. pag. WWWeb, <http://www.disa.mil/info/pao04p.html>. 12 February 1997.
- Greenfield, Kent R., ed. *Command Decisions*. Washington DC: Center of Military History, U.S. Army, 1990.
- Griffin, R. *Management*, 5th ed. Boston MA: Houghton Mifflin Company, 1996.
- Gruber, David J. Chief, Networks Branch, ACC/SCBN. "Command and Control of an Air Expeditionary Force," attachment to electronic mail dated 17 April 1997.
- Gurbaxani, V. and S. Whang. "The Impact of Information Systems on Organizations and Markets," *Communications of the ACM*, 34(1): 59-73 (January 1991).
- Harrison, E. Frank. "A Process Perspective on Strategic Decision Making," *Management Decision*, 34(1): 46-53 (1996).

- Harrison, E. Frank. "Interdisciplinary Models of Decision Making," *Management Decision*, 31(8): 27-33 (1993).
- Hayes, Richard E. and Gary Wheatley. "Information Warfare and Deterrence," *Strategic Forum* 87, Institute for National Strategic Studies, October 1996.
- Heath, Chip and Rich Gonzalez. "Interaction With Others Increases Decision Confidence but not Decision Quality: Evidence Against Information Collection Views of Interactive Decision Making," *Organizational Behavior and Human Decision Processes*, 61(3): 305-326 (March 1995).
- Heminger, Alan. Class lecture, IMGT 671, Information Engineering. School of Logistics and Acquisition Management, Air Force Institute of Technology, Wright Patterson AFB OH, 10 July 1997.
- Henry, Rebecca A. "Improving Group Judgment Accuracy: Information Sharing and Determining the Best Member," *Organizational Behavior and Human Decision Processes*, 62(2): 190-197 (May 1995).
- Holcomb, Robert, Task Leader for Operational Evaluation of Task Force XXI Appliqué and Tactical Internet. Electronic mail message. 24 July 1997.
- Holcomb, Robert, Task leader for Operational Evaluation of Task Force XXI Appliqué and Tactical Internet. Telephone interview. 5 August 1997.
- HQ ACC. "Activation and Responsibilities of Air Combat Command's Information Operations Division." Electronic Message. 271920Z, 28 February 1997.
- Huber, George P. "A Theory of the Effects of Advanced Information Technologies on Organizational Design, Intelligence, and Decision Making," *Academy of Management Review*, 15(1): 47-71 (1990).
- Hutcherson, Norman B. *Command and Control Warfare: Putting Another Tool in the War-Fighter's Data Base*. Maxwell AFB AL: Air University Press, September 1994 (Research Report AU-ARI-94-1).
- Janis, I. L. "Stages in the Decision-making Process," in *Theories of Cognitive Consistency: A Sourcebook*. Ed. R. P. Alberson. Chicago IL: Rand McNally, 1968.
- Johnson, Craig L. "Information Warfare—Not a Paper War," *Journal of Electronic Defense*, 17(8): 56 (August 1994).

- Joint Staff, Joint Requirements Oversight Council. Memorandum for the Under Secretary of Defense for Acquisition and Technology, JROCM 047-95. Subject: Defense Information System Network (DISN) Mission Need Statement (MNS) Washington DC 20318-8000, 30 March 1995.
- "Joint Warrior Interoperability Demonstration 1997." Military Online Information, n. pag. WWWeb, <http://www.jwid97.bmpcoe.org/general/goals.html>. 16 October 1997.
- Jou, Jerwen, James Schanteau, and Richard Jackson Harris. "An information processing view of framing effects: The role of causal schemas in decision making," *Memory and Cognition* 24(1): 1-15 (1996).
- Kerstholt, José H. "Information search and choice accuracy as a function of task complexity and task structure," *Acta Psychologica*, 80: 185-197 (1992).
- Kumon, Shumpei. "From Wealth to Wisdom: A Change in the Social Paradigm," *Proceedings of the Conference on Computer-Supported Cooperative Work (CSCW '92)*. New York: ACM (Association for Computing Machinery) Press, 1992.
- Landauer, Thomas K. *The Trouble With Computers: Usefulness, Usability, and Productivity*. Cambridge MA: MIT Press, 1995.
- Leidner, D. E. and J. J. Elam. "The Impact of Executive Information Systems on Organizational Design, Intelligence, and Decision Making," *Organization Science*, 6(6): 645-663 (November-December 1995).
- Levis, Alexander H. and Michael Athans. "The Quest for a C³ Theory: Dreams and Realities," in *Science of Command and Control: Coping with Uncertainty*. Stuart E. Johnson and Alexander H. Levis. Washington DC: AFCEA International Press, 1988.
- Libicki, Martin. "What Is Information Warfare?" ACIS Paper 3, August 1995. WWWeb, <http://www.ndu.edu/ndu/inss/actpubs/act003/a003cont.html>. 10 April 1997.
- Link, David M. *Information Dominance*. White Paper, 17 November 1995. WWWeb, <http://www-cgsc.army.mil/cdd/info-dom.htm>. 6 August 1997.
- Lynch, James P. "The Global Correlation Engine (GCE): A Brief Description," White paper, electronic mail attachment, 17 July 1997.

- Mann, Edward. "Desert Storm: The First Information War?" *Airpower Journal*, 8(4): 4-14, (Winter 1994)
- Markus, M. Lynne and Daniel Robey "Information Technology and Organizational Change: Causal Structure in Theory and Research," *Management Science*, 34(5): 583-598 (May 1988).
- Masuch, Michael and Perry LaPotin. "Beyond Garbage Cans: An AI Model of Organizational Choice," *Administrative Science Quarterly*, 34: 38-67 (1989).
- Maykut, Pamela and Richard Morehouse. *Beginning Qualitative Research: A Philosophic and Practical Guide*. London/Washington DC: The Falmer Press, 1994.
- McDougal, Yancy B. "Decision Making Under Risk: Risk Preference, Monetary Goals and Information Search," *Personality and Individual Differences*, 18(6): 771-782 (1995).
- McLeod P. L. "An assessment of the experimental literature on electronic support group work: Results of a meta-analysis," *Human Computer Interaction*, 7(3): 257 (1992).
- McSorley, Bill. C4I-Pro JWID 97 Sitrep. Electronic Mail Message. 1 August 1997.
- Medina-Mora, Raul, Terry Winograd, Rodrigo Flores, and Fernando Flores. "The action workflow approach to workflow management technology," in *CSCW '92 Sharing Perspectives —ACM Conference on Computer-Supported Cooperative Work Oct 31 to Nov 4, 1992*. Toronto Canada: ACM Press, 1992.
- Menoher, Paul E. Jr. "Responsive Communications Key to Army Intelligence," in *The First Information War: The story of communications, computers, and intelligence systems in the Persian Gulf War*. Ed. Alan D. Campen. Fairfax VA: AFCEA International Press, 1992.
- Miles, Matthew B. and A. Michael Huberman. *Qualitative Data Analysis: An Expanded Sourcebook* (Second Edition). Thousand Oaks: SAGE Publications, 1994.
- Miller, James Grier. "Potential Applications of a General Theory of Living Systems to the Study of Military Tactical Command and Control," in *Decision Information*. Ed. Chris P. Tsokos and Robert M. Thrall. New York: Academic Press, 1979.

- Mintzberg, H., D. Raisinghani, and A. Theoret. "The structure of "unstructured" decision processes," *Administrative Science Quarterly*, 21: 246-276 (1976).
- Modrick, John A. "Decision Support in a Battlefield Environment," in *Decision Information*. Ed. Chris P. Tsokos and Robert M. Thrall. New York: Academic Press, 1979.
- Molloy, S. and C. R. Schwenk. "The Effects of Information Technology on Strategic Decision Making," *Journal of Management Studies*, 32(3): 283-311 (May 1995).
- Morris, Michael, et. al. "Air Force Material Command Science and Technology: Analysis of Information Needs and Capabilities." Report to AFMC/ST, Wright-Patterson AFB OH, 20 Mar 1997.
- Murphy, Edward, Gary C. Bender, Larry J. Schaefer, Michael M. Shepard, and Charles W. Williamson. "Information Operations: Wisdom Warfare For 2025 (April 1996)." Military conference paper, n. pag. WWWeb, <http://www.au.af.mil/au/2025/volume1/chap01/v1c1-1.htm>. 5 March 1997.
- Myers, Michael D. "Qualitative Research in Information Systems." Excerpt from online journal, n. pag. WWWeb, <http://www.auckland.ac.nz/msis/isworld/index.html#Qualitative Research Methods>. 26 March 1997.
- Paige, Emmett Jr., Assistant Defense Secretary for Command, Control, Communications, and Intelligence. "Striving for Information Superiority." Prepared remarks to the 311th Theater Signal Command Activation Dinner, Fort Meade MD., June 22, 1996. In *Defense Issues*, 11(72), n. pag. WWWeb, <http://www.defenselink.mil/pubs/di96/di1172.html>. 12 February 1997.
- Payne, John W., James R. Bettman, Eloise Coupey, and Eric J. Johnson. "A constructive process view of decision making: Multiple strategies in judgment and choice," *Acta Psychologica*, 80: 107-141 (August 1992).
- Peters, Thomas J. *Garbage Gathering, OODA Loops, Control Conundrums, and other Management Tools for the '90s*. Berkeley CA: TPG Communications, 1991.
- Phelan, Robert G. and Michael L. McGinnis. "Using Process-Oriented Computer Simulation to Reengineer Traditional Stove-Piped Army Staffs for Information Operations in the 21st Century," 224-228 in *Military, Government, and Aerospace Simulation Proceedings of the 1996 Simulation Multiconference--Simulation Series 28(3)*. Ed. Michael J. Chinni. New Orleans: Simulation Councils, Inc., 8-11 April 1996.

- Propp, Kathleen M. and Kelly M. Julian. "Enhancing Accurate Information Processing: An Investigation of Verbal Information Probes in Decision Making," *Communication Reports*, 7(2): 145-152 (Summer 1994).
- Radford, K. J. *Information Systems for Strategic Decisions*. Reston VA: Reston Publishing Company, Inc., 1978.
- Robinson, Clarence A., Jr. "Global Combat Support Speeds Tactical Larder Replenishment," Online article, n. pag. in *Signal* (November 1996). WWWeb, <http://www.disa.mil/gcss/signal.html>. 12 February 1997.
- Rota, Dane L. "Combat Decision Making in Operations Other Than War," *Military Review*: 24-28 (March-April 1996).
- Saunders, Carol and Jack W. Jones. "Temporal Sequences in Information Acquisition for Decision Making: A Focus on Source and Medium," *Academy of Management Review*, 15(1): 29-46 (1990).
- Schechtman, Gregory M. *Manipulating The OODA Loop: The Overlooked Role Of Information Resource Management In Information Warfare*. M.S. Thesis, AFIT/GIR/LAL/96D-10. School of Logistics and Acquisition Management, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, December 1996 (AD-A319636).
- Schrenk, L. P. "Aiding the Decision Maker—A Decision Process Model," *Ergonomics*, 12: 543-557 (July 1969) as cited in Harrison, E. Frank. "A Process Perspective on Strategic Decision Making," *Management Decision*, 34(1): 46-53 (1996).
- Schwartz, Winn. *Information Warfare: Cyberterrorism: Protecting Your Personal Security in the Electronic Age*. New York NY: Thunder's Mouth Press, 1996.
- Shoemaker, Paul J. H. and J. Edward Russo. "A Pyramid of Decision Approaches," *California Management Review*, 36(1): 9-33 (Fall 1993).
- Simon, Hubert A. *Administrative Behavior* (Second Edition). New York NY: Free Press, 1957.
- Slovic, Paul. "Toward Understanding and Improving Decisions," in *Human Performance and Productivity, Volume 2: Information Processing and Decision Making*. Ed. William C. Howell and Edwin A. Fleishman. Hillsdale NJ: Lawrence Erlbaum Associates, Inc., 1982.

- Sloyan, Patrick J. "Computerized Army Fizzles in Face of Friendly Fire Victims," *The Arizona Republic*, Monday, 26 May 1997, A13.
- Smith, Kevin B. "Combat Information Flow," *Military Review*, 69: 42-54 (April 1989).
- Stasser, Garold. "Information Salience and the Discovery of Hidden Profiles by Decision-Making Groups: A 'Thought Experiment'," *Organizational Behavior and Human Decision Processes*, 52: 156-181 (1992).
- Stein, George J. "Information Warfare," Online article, n. pag. In *Airpower Journal* (Spring 1995). WWWeb, <http://www.cdsar.af.mil/apj/stein.html>. 12 May 1997.
- Sterling Software Southeast for Air Force Communications Agency. *Defense Message System--Air Force Concept of Operation--Draft (Version 1.1)*. Montgomery AL, 1 Oct 1996.
- Strauss, Anselm and Juliet Corbin. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. Newbury Park CA: Sage Publications, 1990.
- Streufert, S., P. Suedfeld, and M. J. Driver. "Conceptual structure, information search, and information utilization," *Journal of Personality and Social Psychology*, 2(5): 736-740 (1965).
- Sundström, Gunilla A. "Process tracing of decision making: an approach for analysis of human-machine interactions in dynamic environments," *International Journal of Man-Machine Studies*, 35: 843-858 (1991).
- Szafranski, Richard. "A Theory of Information Warfare: Preparing for 2020," *Airpower Journal*, 9(1): 41-55 (Spring 1995).
- Teresko, John. "Data Warehouses: Build Them for Decision-Making Power," *Information Week*: 43-45 (18 March 1996).
- "Test And Evaluation Master Plan (Temp) for Global Command and Control System V3.0, 2 September 1997." Online military information, n. pag. WWWeb, http://204.34.175.79/new_home/testeval/te_docs.html. 27 September 1997.
- Thomas, Timothy L. "Deterring Information Warfare: A New Strategic Challenge," *Parameters: Journal of the U.S. Army War College*, 26(4): 81-96 (Winter 1996).
- Thomas, Timothy L. "Russian Views on Information-Based Warfare." Online article, n. pag. WWWeb, <http://www.cdsar.af.mil/apj/thomas.html>. 10 April 1997.

- Thow-Yick, Liang. "The Basic Entity Model: A Theoretical Model of Information Processing, Decision Making and Information Systems," *Information Processing and Management*, 32(4): 477-487 (1996).
- Thrasher, Roger D. "Information Warfare Delphi: Raw Results," Online concept paper, n. pag. June 1996. WWWeb, <http://superior.carleton.ca/~rgarigue/delphi.pdf>. 12 May 1997.
- Todd, P. and Izak Benbasat. "The Use of Information in Decision Making: An Experimental Investigation of the Impact of Computer-Based Decision Aids," *Management Information Systems Quarterly*, 16(3): 373-394. (September 1992).
- Toffler, Alvin and Heidi Toffler. *War and Anti War: Survival at the Dawn of the Twenty-First Century*. Boston: Little Brown, 1993.
- United States Army Operational Test and Evaluation Command. *Abbreviated Operational Assessment for the Appliqué and Tactical Internet*. 23 October 1996.
- , *Abbreviated Operational Assessment for the Appliqué and Tactical Internet*. 19 December 1996.
- , *Abbreviated Operational Assessment for the Appliqué and Tactical Internet*. 26 February 1997.
- , *Abbreviated Operational Assessment for the Appliqué and Tactical Internet*. 3 July 1997.
- United States Congress. *Information Technology Management Reform Act of 1996*. Division E of Public Law 103-62, Washington: GPO, 8 August 1996.
- Walsh, Bill. "Blinded by the Byte," *Forbes ASAP*: 22 (24 February 1997).
- Weick, Karl E. "Theoretical Assumptions and Research Methodology Selection," in *The Information Systems Research Challenge Proceedings*, Ed. F. Warren McFarlan. Boston MA: Harvard Business School Press, 1984.
- Witte, E. "Field Research on Complex Decision-Making Processes," *International Studies of Management and Organization*: 156-182 (Summer 1972), as cited in Harrison, E. Frank. "Interdisciplinary Models of Decision Making," *Management Decision*, 31(8): 27-33 (1993).

- Woodcock, A. E. R. "Indications and Warnings as an Input to the C³ Process," in *Science of Command and Control: Coping With Uncertainty*. Ed. Stuart E. Johnson and Alexander H. Levis. Washington DC: AFCEA International Press, 1988.
- Yadav, Surya B. and Deepak Khazanchi. "Subjective Understanding in Strategic Decision Making," *Decision Support Systems*, 8: 55-71 (1992).
- Zwass, Vladimir. *Management Information Systems*. Dubuque IA: Wm. C. Brown Publishers, 1992.

Vita

Captain Stacy M. Clements was born on 18 September 1967. She graduated from Baumholder American High School in 1985 and received her Bachelor of Arts degree from Arizona State University in December of 1988. In November 1992, she entered Officer Training School at Lackland Air Force Base, Texas, where she was commissioned on 31 March 1993.

After completing technical training at Keesler Air Force Base, Mississippi, she was assigned as squadron section commander for the 509th Communications Squadron at Whiteman Air Force Base, Missouri. During her tour there, she was deployed to Dhahran, Saudi Arabia, in support of Operation SOUTHERN WATCH, where she served as the executive officer for the 4404th Operations Group (Provisional). In March 1995, she was assigned to Osan Air Base, South Korea, as the 51st Operations Group executive officer. After completing her one-year assignment there, she was selected to attend the Air Force Institute of Technology. She completed the program and was awarded the Master of Science degree in Information Resource Management in December 1997. Her follow-on assignment is to Air Force Materiel Command, Wright-Patterson AFB, Ohio.

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 074-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE December 1997		3. REPORT TYPE AND DATES COVERED Master's Thesis
4. TITLE AND SUBTITLE THE ONE WITH THE MOST INFORMATION WINS? THE QUEST FOR INFORMATION SUPERIORITY			5. FUNDING NUMBERS	
6. AUTHOR(S) Captain Stacy M. Clements				
7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S) Air Force Institute of Technology 2950 P Street WPAFB OH 45433-7765			8. PERFORMING ORGANIZATION REPORT NUMBER AFIT/GIR/LAL/97D-5	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (<i>Maximum 200 Words</i>) The escalation of interest in information as a corporate resource is reflected in the military's quest for information superiority. A volume of directives, articles, and doctrine is appearing to meet the unique challenges presented by information as a resource. Discussions of how to achieve information superiority have given rise to investigations of such related concepts as information warfare and information operations, with associated taxonomies and ideas of how to use information capabilities for attack and defense. This thesis examines information superiority and the related concepts, and examines current information technology initiatives in order to discern the characteristics which can aid in the quest for information superiority. A synthesis of the most prominent perspectives on information superiority is formed. In the context of this definition, a process model of information superiority and its necessary activities is developed, with acquisition and decision making identified as key. The idea of information technology as enabling information superiority is probed, and an alternate view proposed; contending that information technology is more likely to be detrimental to information superiority unless certain criteria are met. The resulting conceptual model depicts the key attributes of information superiority and information technology, and represents the relationships between these concepts.				
14. Subject Terms Information superiority, information warfare, information operations, decision making, information technology			15. NUMBER OF PAGES 140	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

NSN 7540-01-280-5500

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